LAMPS AND MINERAL OIL

FOR

THE ARMY.

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The subject of furnishing some substitute for candle-light in the Army was often suggested, and from time to time engaged the attention of the War Department after the general introduction throughout the country of mineral oil for illuminating purposes; but there was an indisposition to permit the introduction, even for experiment, of lamps and volatile oils possibly explosive and apparently unsafe and dangerous in unskillful hands.

In January, 1879, Capt. James M. Bell, Seventh Cavalry, addressed a letter to the Adjutant-General of the Army, setting forth the importance of providing better lights for barracks and quarters; calling attention to the mixed oil composed of about two-thirds lard oil and one-third mineral oil in use on railroads for signal-lights; and suggesting the appointment of a Board of Officers to test lamps and oil with a view to their introduction into the Army, if found suitable.

The Commissary-General of Subsistence, to whom the communication was referred, conceded the importance of the subject, and suggested a reference to an officer of the Quartermaster's Department at Philadelphia for a report as to the particular oil referred to by Captain Bell. This reference was accordingly made, and a series of experiments reported by the depot quartermaster at Philadelphia to the Quartermaster-General, showing, in substance, that the signal-oil in use on railroads was non-explosive; that carbon oil of proper quality was also non-explosive if used with proper burners; and that the cost of illuminating with the signal-oil would be four times greater than with mineral oil.

The papers were referred by the Quartermaster-General to the Commissary-General of Subsistence (the Subsistence Department being at that time charged with the duty of furnishing lights for the Army), who returned them, after consideration, suggesting that the papers be submitted to the Secretary of War, with recommendation for the appointment of a Board of Officers by the commanding general Division of the Atlantic for the purpose of examining into and reporting upon the subject of lighting company quarters with oil; also, expressing the opinion that no product of coal-oil which he had ever seen should be purchased by the Subsistence Department for illuminating purposes, because, if such oils were stored with subsistence supplies, the more delicate stores would become impregnated with the odor and taste of oil.

In accordance with this suggestion, the papers were fowarded to the Adjutant-General of the Army for the consideration of the Secretary of War. The Quartermaster-General was of the opinion that, if the danger of the use of mineral oil was to be incurred, the student or argand petroleum lamp was preferable to the railroad signal-lamp. He was, however, in view of accidents constantly reported, in favor of using more candles, if necessary to have more light.

The General of the Army did not favor the appointment of a Board; did not believe that a Board could solve the problem; thought experience was the only test; believed that the lamps and oil in common use should be used unless better were invented; that candles were better in the West on account of safety in carriage, while near cities officers will use what lights they consider best; did not consider uniformity in candles, lamps, and oil desirable; and thought that, as in the case of fuels, each post should use those easiest supplied.

The Inspector-General concurred in the views of the General of the Army; did not believe that a Board would develop anything new or valuable on a subject which experts had studied for years; did not favor the introduction of volatile oils; and believed candles better adapted for Army use than oil lamps.

Upon another reference to the Commissary-General of Subsistence that officer urged that something be done to give the Army better lights, to afford to enlisted men the opportunity to spend their evenings in their quarters profitably for recreation or instruction; did not believe that this result could be attained with any allowance of candles as cheaply as with lamps and oil; and considered it his duty to again urge the appointment of a Board.

The Inspector-General, without changing his views as to the proper lights for the Army, admitted that it might be well to have a Board convened to take the subject into consideration.

June 21, 1879, the Secretary of War directed that a Board be convened, as recommended by the Commissary-General of Subsistence.

Accordingly, a Board of Officers, of which Col. N. H. Davis, Inspector-General, was president, was convened by Special Orders No. 26, Headquarters Division of the Atlantic, June 30, 1879, to meet at Fort Columbus, New York Harbor, "for the purpose of fully examining into and reporting upon the subject of lighting company quarters with oil," &c. The report of this Board, containing the record of careful and elaborate experiments and a recommendation for the supply of lamps and mineral oil to the Army, having been referred by the Secretary of War to the Quartermaster-General, was returned by him with the recommendation that steps be taken for the introduction into the Army of the system of lighting barracks and quarters recommended by the Board, and giving his views at length as to the style of lamp to be used and the precautions necessary to prevent accident.

August 7, 1880, the papers were returned to the Quartermaster-Gen-

eral, with the views of the Commissary-General of Subsistence and the Inspector-General indorsed thereon (concurring, substantially, in the expediency of the proposed change in the system of lighting barracks and quarters), for an expression of his views as to the sufficiency of the appropriation for incidental expenses of the Quartermaster's Department for the purchase of lamps and oil, to carry out the recommendation of the Board—this having been suggested by the Inspector-General.

August 12, 1880, the Quartermaster-General referred all papers on the subject to a Board of Officers, consisting of Col. S. B. Holabird, Assistant Quartermaster-General, Lieut. Col. H. C. Hodges, Deputy Quartermaster-General, and Maj. J. M. Moore, Quartermaster, with instructions to prepare estimates of the expenditure required for the introduction throughout the Army of mineral oil and lamps; also, it being evident that the appropriation for the current year would not justify the attempt to supply all military posts at once, to prepare a list of posts where trial could be made, the system to be extended to others should the result of the trial prove satisfactory and should Congress grant the necessary appropriation.

This Board having submitted recommendations as to the quality of oil proper to be used and the method of packing it for shipment to posts; the kind of lamps and fixtures best suited for Army use; the ratio of issue to troops; the posts to be first supplied; with estimates of cost, &c.; the Quartermaster-General reported August 21, 1880, that the appropriation for incidential expenses was legally applicable, so far as available, for lighting military buildings, and recommended the introduction of the system so far as the appropriation would admit, the expense there after to be borne by the appropriation of the Quartermaster's Department for regular supplies.

The recommendation having been approved by the Secretary of War, lamps of various patterns and mineral oil were procured and sent to certain posts for trial.

After protracted correspondence and much careful experiment in the office of the Quartermaster-General, the Army lamp in present use was perfected and adopted for use, procured by contract, under advertisement, and issued to the Army. After receipt of the reports from the posts first supplied with the new lights, general instructions were prepared and promulgated to the Army in General Orders No. 50, Adjutant-General's Office, 1881, and this order, with slight modification (General Orders No. 80, Adjutant-General's Office, 1882), governs the subject and regulates issues.

May 16, 1883, Lieut. Col. H. C. Hodges, Deputy Quartermaster-General, called the attention of the Quartermaster-General to a lamp which had been submitted by Mr. J. F. Donnell, of New York City, of which he had formed a very favorable opinion, and recommended that it be tried in comparison with the adopted pattern of lamp, with a view to

determining its adaptability, if found superior, for Army use. The Quartermaster-General (General Ingalls) recommended that a mixed Board be appointed to examine and report upon the merits of this lamp. In accordance with this recommendation, a Board of Officers, of which Lieut. Col. R. Jones, Assistant Inspector-General, was president, was convened by Special Orders No. 127, Adjutant-General's Office, June 4, 1883, to meet at Army Building, New York City, for the purpose. July 20, 1883, the scope of the powers of the Board was enlarged to include an examination into other lamps of different patterns.

The report of this Board, dated December 7, 1883, recommending the adoption of the lamp known as the "Mitrailleuse," was referred by the Adjutant-General of the Army to the Quartermaster-General for remark, December 11, 1883.

REPORT ON LIGHTING COMPANY QUARTERS, ETC.

BY A BOARD OF OFFICERS.

GOVERNOR'S ISLAND,
New York Harbor, November 20, 1879.

The ASSISTANT ADJUTANT-GENERAL,
Military Division of the Atlantic,
Governor's, Island New York Harbor:

SIR: The Board of Officers convened pursuant to Special Orders No. 26, Headquarters Military Division of the Atlantic, of June 30, 1879, respectfully submits the following report, and returns herewith the papers submitted for its consideration:

Proceedings of a Board of Officers convened pursuant to the following order:

SPECIAL ORDERS No. 26. HDQURS. MILITARY DIVISION OF THE ATLANTIC, *Governor's Island, New York Harbor, June* 30, 1879.

By direction of the Secretary of War, a Board of Officers to consist of Col. Nelson H. Davis, Inspector-General; Col. Marcus D. L. Simpson, Assistant Commissary-General of Subsistence; Asst. Surg. James P. Kimball, Medical Department; Capt. Joseph P. Sanger, First Artillery; First Lieut. Charles Bird, Twenty-third Infantry, is hereby appointed to meet at Fort Columbus, New York Harbor, on Wednesday, the 2d of July, 1879, at 11 o'clock a. m., or as soon thereafter as practicable, for the purpose of fully examining into and reporting upon the subject of lighting company quarters with oil. The Board will make experiments with various oils, and will report the kind of lamp best adapted to the purpose of burning the oil recommended by it, the number of such lamps required to properly light a company barrack-room of the authorized size, and the average quantity of oil consumed per lamp per hour.

The Chief Quartermaster of the Division will purchase such lamps, and the Chief Commissary of Subsistence such oil and wicks as may be required for the purpose indicated.

The Board will also examine and report upon a recently invented "candle-lamp," or "holder," for burning tallow, adamantine, or other candles.

Papers bearing upon the subject will be sent to the Board for its information and for attention in connection with its deliberations.

By command of Major-General Hancock.

WILLIAM G. MITCHELL,
Captain, Fifth Infantry, Acting Assistant Adjutant General.

Official:

JOHN S. WHARTON,
Captain, Nineteenth Infantry, Aide-de-Camp.

GOVERNOR'S ISLAND, NEW YORK HARBOR.
July 2, 1879.

The Board met pursuant to the above order.

Present, all the members.

The following-named papers, received from the Headquarters Military Division of the Atlantic, were read and filed for further consideration, to wit: Letter of instructions from Headquarters Military Division of the Atlantic; indorsements on communication of Post Treasurer, Plattsburg Barracks, &c.; letter of Captain Bell, Seventh Cavalry, and indorsements thereon; letter of E. Lewis, Pennsylvania Railroad Company, to Captain Lord, Assistant Quartermaster, &c.; copy of letter from Charles B. Dudley, chemist, with indorsements; indorsement on papers relative to convening of Board, &c.; letter of Adjutant-General to Commissary-General, with indorsements thereon; General Orders Nos. 17 and 42 of 1870, and 55 of 1877.

The Board then adjourned to meet at the call of the president.

GOVERNOR'S ISLAND, NEW YORK HARBOR,
July 17, 1879.

The Board met, pursuant to previous adjournment.

Present, all the members.

Between its first meeting and this date the Board held informal meetings for the transaction of business.

In consideration of the nature and scope of investigation required of the Board, and of the other duties its members had to perform, it determined to meet at the call of the president from time to time, as duties and circumstances permitted; to keep no formal record of its meetings, but to note the results of experiments made, and the information gained; to visit persons and places to acquire information; to procure instruments for the purpose of making tests, and to solicit manufacturers and dealers in oils, lamps, burners, &c., to submit samples for examination and trial.

GOVERNOR'S ISLAND, NEW YORK HARBOR,
September 10, 1879.

The Board met to-day at the call of the president.

Present, all the members, including Surg. J. H. Janeway, U. S. A., who relieved Asst. Surg. J. P. Kimball, U. S. A., pursuant to the following order:

SPECIAL ORDERS } HDQRS. MILITARY DIVISION OF THE ATLANTIC,
No. 59. } *Governor's Island, N. Y. H., September* 8, 1879.

[Extract.]

1. Surg. J. H. Janeway, U. S. Army, is hereby detailed a member of the Board of Officers convoked by paragraph 1, Special Orders No. 26, current series, from these headquarters, vice Asst. Surg. J. P. Kimball, under orders for the Military Division of the Missouri.

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By command of Major-General Hancock.

WILLIAM G. MITCHELL,
Captain, Fifth Infantry, Acting Assistant Adjutant-General.

Official:

Signed, JOHN S. WHARTON,
Captain, Nineteenth Infantry, Aide-de-Camp.

The Board, after transacting its business, adjourned to meet at the call of the president.

GOVERNOR'S ISLAND, NEW YORK HARBOR,
November 20, 1879.

The Board met pursuant to last adjournment.

Present, all its members.

The following report of the Board has necessarily been delayed by frequent and unavoidable interruptions, by other duties which devolved upon members, and by causes beyond its control.

Under the instructions received, it is directed to fully examine into, and report upon, the subject of lighting company quarters with oil; to experiment with various oils; to determine the best lamp for burning the oil recommended; the number thereof for properly lighting a barrack room; the average quantity of oil consumed per lamp per hour; to report upon a "candle lamp" or "holder" referred to for burning candles, and to test and report upon the oil sold by the post trader of Governor's Island, &c.

Also, "to take into consideration and report upon the subject of proper allowance of candles to be issued to troops, &c., in different latitudes and at different seasons of the year, * * * taking the present uniform allowance of candles (one and a quarter pounds to the hundred rations) as the proper allowance for nights of mean length at posts of mean latitude."

The instructions to the Board, considered in connection with the contents of the papers referred to it, and the importance of the subject of

inquiry to the Army, not only authorize, but in its judgment seem to require, that the scope of its investigations should extend to the determination, so far as practicable, of the most suitable means of lighting company quarters (including mess, kitchen, and reading rooms), as well as hospitals, guard-rooms, shops, storehouses, stables, public grounds, &c., and officers' quarters, where gas is not used, at the same time of fulfilling the conditions of *good* and *adequate* light, of *safety* in its use, of *facility* in supplying at reasonable cost the materials therefor, and the *feasibility* of their transportation and storage with *security*, taking into consideration different latitudes and seasons of the year.

After a careful and protracted investigation by the Board of the subject-matter submitted to it, having obtained information derived from various tests, experiments, and examinations it has witnessed and made; from consultations with dealers in oils, candles, lamps, &c., and from other sources, it reports *results*, and, as believed, its conclusions and recommendations are based upon substantially *correct data*.

Through the courtesy of Col. J. C. Duane, United States engineer, photometric with other experiments have been made by and with the aid of his expert, Mr. J. Funck (formerly an assistant to the late Professor Henry), at the Light-House Depot, Staten Island, New York Harbor, where scientific appliances and special facilities were available.

Most of the pyrometrical, hydrometrical, with photometrical and other experiments were made at Governor's Island, New York Harbor, under the direction and supervision of the Board by General Service Clerk S. H. Story, whose knowledge of oils and experience in making instrumental and other tests made him an efficient assistant.

The several divisions of the subject-matter are considered in the following order, to wit:

Oils, candles, candle-holder, lamps (including burners, wicks, and chimneys), conclusions, and recommendations.

OILS.

Mineral, animal, vegetable, and fish oils are the kinds principally used for purposes of illumination. Mixed oils, made usually by mixing in certain proportions animal and mineral oils, are somewhat used.

Sperm and *lard* are the animal oils most used for illumination, and, because of the high heat (500° to 700° F.) required to vaporize them, are called non-explosive; they chill and congeal from 44° to 26° F., at which temperatures they need artificial heating to fit them for burning in lamps; consequently, in very cold weather, they must be liquified by heat before they can be used. In warm weather or at ordinarily high temperatures these oils burn well in lamps suited to their combustion, giving a good light.

In the large "fountain lamps" of the Light-House Department, in which lard oil is burned, the oil is pumped into a reservoir directly over

the large Argand flame, which keeps it hot, whence it is fed through a tube to the burner.

The "winter-strained" or "bleached" qualities, which have removed the portion that soonest chills when exposed to cold, are the best for use in high latitudes and cold seasons, but in the case of lard oil the bleached has less illuminating power than the unbleached quality. Sperm gives about 5 per cent. less candle-power than lard oil.

Mixed oils are objectionable for house lights because of the smoke and disagreeable odors generally emitted by them, and because they may, and probably do, contain *light* carbon oils, which make them nearly as dangerous from fire and explosion as are the volatile products with which they are mixed. In addition, their relatively high cost, when containing animal oils, as compared with better and safe ones, justifies their rejection for indoor illumination. For "signal" and "switch" lights they are used.

The sample of mixed oil used by the Pennsylvania Railroad Company, submitted to and tested by the Board, gave in the lantern lamp furnished 2.19 candle power, emitted an offensive odor with smoke, rose to 122° F. in the fount, flashed at 130° F., and ignited at 176° F. Its composition is reported to be two-thirds extra lard and one-third 150° kerosene oil. Mr. Dudley, chemist, employed by the railroad company, reports its candle power at 1.58 in a No. 2 lard-oil burner, with the wick ordinarily used in it.

As *good* 150° F. kerosene oil flashes at about 125° F., which is only 5° below the "flash point" of the Pennsylvania Railroad sample in the pyrometrical test made of it, this experiment refutes the idea entertained that the *mixture* of animal with mineral oils is non-inflammable and non-explosive.

This sample chilled at 25° F. and solidified at 10° F., showing that such mixtures require in low temperatures heating from some source to make them suitable for illumination.

Colza oil (vegetable) is so little used in this country its consideration may be disregarded.

Kerosene or *carbon oils* (mineral) are, *par excellence*, most universally used for purposes of illumination.

In brilliancy and softness of light produced, in the nearly odorless and smokeless flame from the best qualities now manufactured, when burned in suitable lamps, and in cheapness, they stand unequaled, and challenge the world for a rival.

These oils are made from crude petroleum and belong to the hydrocarbon series.

For information concerning them derived from a knowledge of the process of their manufacture, which may be beneficial to those in the Army using them, the following brief description is given:

The crude petroleum is put into iron stills and gradually heated. After the gaseous products (*cymogene* and *rhigolene*) are driven off, come the

highly volatile *gasolene*, *naphtha*, and *benzine* oils, classed sometimes as *naphtha*, having a gravity of 95° to 60° Beaumé, which are run into tanks. These volatile and very inflammable products evolve at ordinary low temperatures vapors which ignite by contact with a flame, and constitute when mixed with air in proper proportions (in volume 5 or more of air to 1 of vapor) explosive compounds. They are dangerous when burned in lamps unmixed or mixed with other oils. As reported, they are used to adulterate good oils; also have been mixed with various ingredients and sold under different names as non-explosive burning fluids.

The next products of the stills are the kerosene oils proper, which have a gravity of about 60° to 35° B., and are run into tanks according to density, between the gravities just given. Thence they go to the agitators, where they are treated with sulphuric acid and alkali to bleach and sweeten them—*i. e.*, to remove coloring matter and odors—and afterwards, for making the best and safest burning oils, to large shallow tanks for exposure to sunlight and air, where they are heated (by steam pipes) to eliminate any naphtha that may have remained, to make the mass more homogeneous in character, and sometimes they are re-distilled.

After the kerosene, the distillation produces a heavier grade of oil, from which, by a process of chilling, hydraulic pressing, and other treatment, are manufactured paraffine wax for candles, and lubricating oils, or it is "cracked" in high stills into lighter oils and again distilled with the petroleum.

The vapor of carbon oils is not, *per se*, inflammable or explosive, and is so only when mixed with air. But oils that vaporize at ordinary temperatures are dangerous for burning in ordinary lamps, because the vapor they evolve is liable, after mixing with air, to come in contact with the flame. When the lamp is lighted, and more especially if the fount is but partly filled and the flame is driven into the fount by blowing down the chimney to extinguish it, or when the oil is spilled or thrown out of the lamp by its breakage or by agitation, is this danger more imminent. The best guaranty of safety in burning kerosene oil is to use a quality that does not vaporize at the temperature it will reach in the fount and to use suitable lamps. Under the head of lamps the proper ones for this oil are considered.

The specific gravity of a kerosene oil is not a safe index of its volatile and inflammable character, for a comparatively heavy specimen may contain a percentage of a very light oil, or naphtha. The proper and correct way to determine if an oil is inflammable at low or ordinary temperatures is by a pyrometrical test.

Tagliabue's pyrometer, with "closed cup," used by the Board, gave uniform and reliable results. The "open cup" is not considered as correct.

Commercially, kerosene oils are graded according to their "burning points," *i. e.*, the temperature at which they will take fire. But the

proper and only real safe test is the "flash point," the temperature at which inflammable vapor is first evolved, which, in the experiments made by the Board, was shown to be from 25° to 57° F. below the fire point of commerce, and the latter is from 3° to 20° F. higher than it was shown to be in the experiments referred to.

The greatest difference between the *flash* and *fire* points was found in heavy oils. In one instance, the result of three separate tests, it was 90° F., and accounted for upon the supposition that the sample tried was a mixed oil.

In the Board's experiments at Light-House Depot, Staten Island, the highest temperature the oil reached in twenty-three metallic lamps, after seven hours' burning with maximum flame, in a room at about 80° F., was 107° F.; and with four glass lamps, temperature of room about the same, the highest reached was 99° F.

Prof. C. F. Chandler reports the results of his experiments with kerosene oils, to wit:

FIRST SERIES.—TEMPERATURE OF ROOM, 73° TO 74° F.

[After seven hours.]

	11 metallic lamps.	12 glass lamps.
	° *F.*	° *F.*
Highest temperature reached	100	86
Lowest temperature reached	76	76
Average temperature reached	86	81

SECOND SERIES.—TEMPERATURE OF ROOM, 82° TO 84° F.

[After four hours.]

	13 metallic lamps.	12 glass lamps.
	° *F.*	° *F.*
Highest temperature reached	120	91
Lowest temperature reached	82	84
Average temperature reached	96½	86

THIRD SERIES.—TEMPERATURE OF ROOM, 90° TO 92°F.

[After four hours.]

	13 metallic lamps.	12 glass lamps.
	° *F.*	° *F.*
Highest temperature reached	129	98
Lowest temperature reached	84	85
Average temperature reached	104½	92⅓

The highest temperatures he reported as exceptional. It will be noticed that the temperature of the oil is higher in metallic than in glass lamps.

Therefore, with rare exceptions, it would seem that an oil with a

"flash point" at 120° to 125° F., properly used in good lamps, is safe. Its real "burning point" would be about 143° F. A higher grade of oil, however, is considered safer and better under all circumstances.

The lighter oils burn more freely and give usually a more brilliant light, especially in capillary lamps, but their consumption is greater than with the higher or heavier grades; they are less, or little, affected by extreme cold.

If these oils contain free acid after their treatment with alkali, &c., except in nearly an inappreciable quantity, they will corrode metallic lamps when used in them, and form upon the chimneys a whitish deposit.

When purchased in quantity they should be tested with litmus paper for acid.

If the acid is neutralized, and the resulting salt is not removed, it constitutes an impurity which affects, more or less, the brilliancy of the light, hence the less of this salt in the oil the better its quality.

As directed, the Board has tried and tested pyrometrically the oil sold by the post-trader at Governor's Island, and its quality is shown by the following table, to wit:

Date.	Flash point.	Fire point.	Gravity.
	° *F.*	° *F.*	
July 26, 187?	120	142	Not taken.
August 14, 1879	118	140	Not taken.
November 10, 1879	114	145	49.1 B.

The results show that the sample first tested was the most homogeneous in character and the best for use.

The sample last tested shows that it contained lighter grade oils than the other samples.

The following data concerning the manner of shipping oils, average weight, and cost of packages, &c., is that obtained from manufacturers and dealers:

Oils.	Capacity.	Weight.	Cost of packages.
	Gallons.	*Pounds.*	
Kerosene:			
*Barrels	50	70	$1 30
†Cases	10	18½	80
Sperm:			
Barrels	45 to 50	70	1 30
Casks	100 to 300	.....	.....
Lard, barrels	45 to 50	67	1 25

* Heavy oak, iron hooped, and glued inside; white-wood bungs, kiln dried, and put in with glue; 40 gallons in barrel; can be refilled; if not, and returned serviceable, paid for.

† Two 5-gallon tin cans in each wooden case; can be refilled; if not, and returned serviceable, paid for; cost 3½ to 5 cents more per gallon than in barrels if packages are not returned; they are so made as to be used as filling cans; cases also contain one 10-gallon can, and ten 1-gallon cans.

The average weight of oils as reported is, for—

		Pounds.
Sperm	per gallon	7.25
Lard	do	7.6
Kerosene of 110° to 150°	do	6.5
Kerosene of 200°	do	6.75
Kerosene of 300°	do	7.

CANDLES.

Adamantine, sperm, paraffine, tallow, and wax candles are the kinds mostly used for illumination; for Army use, the wax candle, on account of its high cost, and the "tallow dip," because little used for house lights, and of its poor light and greasy character in hot weather, may be disregarded.

The results of several tests with the three remaining kinds above mentioned, made under the most favorable conditions, being carefully snuffed to avoid coaled wicks, and excluded from currents of air, are given in the following table, to wit:

Candles.	Average weight.	Consumption per hour.	Time of consumption theoretically.	Time of consumption practically.
	Grains.	*Grains.*	*Hours.*	*Hours.*
Adamantine	1176.3	168.7	8.9	6.57
Sperm	1051	112.63	9.20	8.16
Paraffine	1019	100.83	10.6	9.42½

The photometrical power compared with the "standard candle," and the relative power of the adamantine and paraffine without snuffing the wick, is given below, to wit:

Candles.	Standard candle, average power.	Relative power first 10 minutes.	Relative power second 10 minutes.	Relative power after 20 minutes.
Adamantine	1.05	1.10	.76	.60
Paraffine	.80	.90	1.24	1.40

The wick of the admantine coals and clouds the flame unless frequently snuffed; the sperm has the same defect in a less degree; the paraffine is more nearly free from this coaling, its wick being consumed as the candle is burned; it therefore gives a more uniform and the most light, as compared with the adamantine, unless the latter is kept well snuffed, as above shown, and in point of consumption it has about 40 per cent. in its favor.

Paraffine wax as now made melts not below 132° F.

The cost of the three kinds of candles above considered, in quantity, at the present prices current, is, per pound, about 15 cents for adaman-

tine, 18 cents for paraffine, 25 cents for sperm, and 35 cents for patent sperm, with an upward tendency in the market price.

Sperm and paraffine candles are packed 36 in a box, and six of these small boxes are packed in a larger one, the net and gross weights of which being, respectively, 31½ and 41 pounds.

Adamantine candles are packed 180 in one box, the net and gross weight being, respectively, 30 and 36¼ pounds.

The adamantine is the kind now issued to troops, at the rate of 20 ounces to 100 rations, which gives to a company of 40 average strength, 15 pounds *monthly* or 3 candles *daily*, to furnish light for the first sergeant's, squad, mess, and kitchen rooms, all of which require lighting. With this allowance, it is reasonable to expect that the soldiers will find their quarters dark, cheerless, and uninviting, and that they should ask for more light; the somber stove now used for heating barracks, and around which they gather in the long winter evenings, gives not that blaze of light and cheer they were wont to enjoy in former days from big wood fires in capacious fire-places, that lighted and warmed their rooms.

To promote the comfort and add to the general welfare of the enlisted men of the army, some other and better than the beggarly light furnished by the flickering flame of a single candle should, it is thought, be given them.

With regard to determining the proper allowance of candles to be issued in different latitudes, directed in letters of the Adjutant-General to the commanding general Division of the Atlantic of the 9th and 28th of last August, and indorsement of the Commissary-General, of the 21st same month, the Board reports that it is found, in respect to latitude, that various conditions exist which do not seem to admit of recognition in a system that shall be productive of good, simple, practicable, working results. Among such conditions may be mentioned the very short twilight of a low latitude, like that of Fort Brown, making artificial light necessary earlier, after sunset, than in a high latitude, like that of Fort Pembina, the greater solar heat in a low latitude making candles burn away faster than in a high latitude, &c. For reasons, such as those suggested, the Board adopts the doubt expressed by the Commissary-General as to whether "any variations should be made on account of latitude," and restricts its report to the subject of the "proper allowance of candles to be issued to troops," &c., "at different seasons of the year * * * taking the present uniform allowance of candles (1¼ pounds to the 100 rations) as the proper allowance for nights of mean length." * * * The Board also considered "what issues shall be made in the different months of the year," and "the question of issue to guards." Exhibits herewith in tabulated form (A and B) show allowances of candles considered for "each month of the year," for "each season of the year," and for "summer and winter periods;" for "issues to troops," and "issues extra"—guards respectively—upon the basis

directed in the instructions herein referred to. The allowances most approved by the Board, as involving fewer changes, and, because of such instructions, recommended, are those appearing in last columns of the exhibits herewith.

The foregoing is submitted as the report required under the instructions herein referred to.

The Board reiterates that it deems the present allowances of candles (20 ounces per 100 rations for general issues, and 12 pounds per month for guards) as entirely inadequate to a proper lighting of soldiers' quarters, &c., even for the shortest nights; in fact, as only rendering darkness visible—creating gloom and dullness where all should be bright and cheerful. The soldier should have ample light for night duties, study and recreation, in order that he may be better fitted for the services he is expected to perform; and any allowances of light necessary for such purpose should be liberally granted.

Exhibit A.

FOR "ISSUES TO TROOPS."

Allowance of candles, considered for each month of the year, for each season of the year, and for summer and winter periods, taking the present uniform allowance (20 *ounces per* 100 *rations*) *as the proper allowance for nights of mean length* (12 *hours**).

Months.	Allowance.		Months.	owance.		Months.	Allowance.	
	Actual.	Round Figures.		Actual.	Round Figures.		Actual.	Round Figures.
			Spring:			Summer period:		
	Oz.	*Oz.*		*Oz.*	*Oz.*		*Oz.*	*Oz.*
January	$23\frac{1}{3}$	23	March (mean)	$18\frac{1}{3}$	18	April	17	17
February	$21\frac{2}{3}$	22	April	$18\frac{1}{3}$	18	May	17	17
March (mean)	20	20	May	$18\frac{1}{3}$	18	June (shortest)	17	17
						July	17	17
			Summer:			August	17	17
April	$18\frac{1}{3}$	18						
May	$16\frac{2}{3}$	17	June (shortest)	$16\frac{2}{3}$	17	Winter period:		
June (shortest)	15	15	July	$16\frac{2}{3}$	17			
			August	$16\frac{2}{3}$	17	Sept. (mean)	22 1-7	22
						October	22 1-7	22
			Fall:			November	22 1-7	22
						Dec. (longest)	22 1-7	23
July	$16\frac{2}{3}$	17	Sept. (mean)	$21\frac{2}{3}$	22	January	22 1-7	22
August	$18\frac{1}{3}$	18	October	$21\frac{2}{3}$	22	February	22 -7	22
September (mean)	20	20	November	$21\frac{2}{3}$	22	March (mean)	22 1-7	22
			Winter:					
October	$21\frac{2}{3}$	22	Dec. (longest)	$23\frac{1}{3}$	23		240	240
November	$23\frac{1}{3}$	23	January	$23\frac{1}{3}$	23			
December (longest)	25	25	February	$23\frac{1}{3}$	23			
	240	240		240	240			

* Round figures.

EXHIBIT B.

FOR "ISSUES EXTRA"—GUARDS.

Allowance of candles, considered for each month of the year, for each season of the year, and for summer and winter periods, taking the present uniform allowance (12 pounds per month) as the proper allowance for months having nights of mean length (12 hours).*

Months.	Allowance, actual.	Months.	Allowance, actual.	Months.	Allowance.	
					Actual.	Round figures.
	Lbs.	SPRING.	*Lbs.*	SUMMER PERIOD.	*Lbs.*	*Lbs.*
January	14	March (mean)	11	April	$10\frac{1}{5}$	10
February	13	April	11	May	$10\frac{1}{5}$	10
March (mean)	12	May	11	June (shortest)	$10\frac{1}{5}$	10
		SUMMER.				
April	11	June (shortest)	10	July	$10\frac{1}{5}$	10
May	10	July	10	August	$10\frac{1}{5}$	10
				WINTER PERIOD.		
June (shortest)	9	August	10	September (mean)	$13\frac{2}{7}$	13
		FALL.				
July	10	September (mean)	13	October	$13\frac{2}{7}$	13
August	11	October	13	November	$13\frac{3}{7}$	14
September (mean)	12	November	13	December (longest)	$13\frac{2}{7}$	14
		WINTER.				
October	13	December (longest)	14	January	$13\frac{2}{7}$	14
November	14	January	14	February	$13\frac{2}{7}$	13
December (longest)	15	February	14	March (mean)	$13\frac{2}{7}$	13
Total	144	Total	144	Total	144	144

* Round figures.

CANDLE-HOLDER.

The "candle-holder," which the Board is directed to examine and report upon, is the pattern of brass candlestick used by Army officers many years since. It has a cylindrical tube, into which is put the candle by compressing a spiral spring intended to push it up as burned away; a cap-section, slightly conical at the top, and open, is adjusted to the upper part of the main tube, which holds down the candle.

The objections to this candlestick are, that the spring clogs with melted parts of the candle that drip into it—in one trial $82\frac{1}{2}$ grains—from which cause, and sometimes that of its weakness, it does not regularly and sufficiently raise the candle as burned; consequently, the flame gradually sinks within the cap-section, and, for want of oxygen, ceases to vaporize the candle, consumes its wick, and frequently goes out; that it is difficult or impossible then to relight the candle in the tube, and after the melted and soft parts of it have cooled and hardened, it is also difficult to get it out, or the spring to be cleaned. These ob-

jections to it, made in former years, are now made by officers at Governor's Island, who have recently practically tested it.

To this "candle-holder" is adjusted a parabolic reflector, with an opening cut on one side, through which passes the candle tube, so that the candle flame shall be in the focus, which is about three-quarters of an inch from its vertex; over the flame is cut a circular opening, about 1¼ inches, for draft and the passage of smoke.

This reflector casts a beam of light (with a small cross-section), which strikes the horizontal plane on which stands the holder, about 30 inches from its base; this reflected beam of light increases, within a limited space, the illuminating power of the naked candle 5.5 to 18.8 times, as was shown by photometrical experiments; in one instance, just after snuffing the candle-wick, the flame flashed a beam which gave 25.18 candle power; the intermittent flaring and flashing of the flame often made it difficult to properly adjust the reflector of the photometer, and take its reading. The average of the most satisfactory results showed about 9 to 12 candle power, if the candle was kept well snuffed; if not, it soon diminished to one-half this power. These trials were made with new, highly-polished nickel-plated reflectors.

While this reflector improves so much the light of a single candle thrown upon a book or paper for reading or writing, or upon some object to be examined, when placed within the beam, and lights much better a limited portion of a room than does the candle without it, these advantages, it is found by trial, are coupled with disadvantages, *as*, the difficulty of keeping the book or paper referred to properly adjusted to the beam of light; the unsteadiness of the light caused by the flickering candle-flame, and the presence of a light shadow, which flits and dances over the paper when reading or writing, which is very annoying and trying to the eyes; moreover, sometimes the currents of air through the circular opening put out the light, and two persons cannot well read or write by it at the same time.

A chimney about 2 inches high was put on the reflector, which increased the draft and caused the flame to flicker less, but one-fourth to one-third of its volume intermittently darted through the chimney hole and up the chimney; the flitting shadow continued.

The Board has suggested that the chimney-opening be cut slightly elliptical and higher on the reflector, that the cap-section be made cylindrical, with an internal flange at top to hold in the candle, and that a joint be made in the candle-tube near its base to give it motion of a few degrees in a vertical plane and laterally, which modifications, it is believed, would be improvements.

LAMPS.

The Board has examined and experimented with a great variety of lamps, to find such ones as will give a good light, reduce the danger

from use, if any, to the minimum, be durable and reasonable in cost, and, generally, well adapted for the purposes for which they are required.

The complete lamp includes the burner, wick, and chimney, besides the font which contains the oil, which are the principal and important parts to be considered. The quality and power of the light produced, depend mainly upon the *burner*, *wick*, *chimney* and *oil* used, and the *manner* it is supplied from the font to the wick; these different parts, and the oil, are considered under their respective heads.

The two general classes into which lamps are here divided are, first, the one in which the oil is fed to the flame by capillary attraction, and called *capillary lamps;* the other class includes those in which the supply of oil to the flame is regulated by atmospheric pressure and gravitation, represented by the "student's lamp," and varieties of this, called *constant-level lamps*, and modifications of these.

In capillary lamps the wick raises the oil, which labor it does very well if of a suitable kind, with rather light oils in comparatively shallow fonts. With heavy oils this labor is greater, and the wick, in deep fonts, as the oil is consumed, fails to supply it in a constant quantity, whereby the light gradually diminishes in brilliancy.

In the constant-level lamps, the oil is so supplied to the wick as to preserve its constant level with regard to the flame, thus maintaining its power and intensity until the font is exhausted. In this class of lamps heavy or light oils can be satisfactorily used, and danger from their ignition or explosion is virtually eliminated.

Metallic fonts are more durable and not so liable to break as are the glass ones, but, as before stated, increase relatively somewhat the temperature of the oil in the font, although not enough to make them objectionable with good oil of 150° F. commercial grade.

The two classes of lamps mentioned, with their modifications, are used as stand, bracket, and swing or pendent lamps; they are made of a variety of forms and styles, to please the eye and gratify the taste.

Several patterns of the constant-level lamp have been made for the Board for its trials and experiments, designed for use as stand, bracket, or pendent lights, including both the round and flat wick kinds, and to be used wth adjustable reflectors.

The most satisfactory patterns tried are the Funck, Manhattan, and Cleveland Non-Explosive Company's lamps.

The expansion of kerosene oil by heat (which is somewhat greater than that of sperm and lard), and its peculiar property of great *surface attraction* or power of creeping over surfaces, will often account for the film of oil on the outside of the lamp after having been cleaned and filled (too full), which the housekeeper usually attributes to leakage. This thin spread of oil soon vaporizes by heat, hence the odor, sometimes unaccounted for, and sometimes ignition; the more highly polished the surface the less will be this spread of oil-sweating.

No particular form of lamp has been tried for lighting post grounds;

the ordinary metallic fount shaped to fit the holder for it, with whichever kind of oil used, is deemed suitable.

For lighting stables, storehouses, etc., and for the use of guards, the Board has tried with satisfactory results, the "tubular lantern," and modification of it as a hanging or bracket lantern; the latter has a reflector, and gave with 200° kerosene oil, 23.10 candle power; the hand or hanging lantern, with an "A" burner and 200° oil, gave 6.24 candle power, with one ounce consumption per hour; it can be swung around and over the head without extinguishing the light. The lamps in both can be lighted or put out without being removed. With regard to the light given and safety in its use, these lantern lamps are considered the best within the knowledge of the Board. Report says that the Franklin Institute pronounced this the best lantern; they are used in the Light-House Department. They are made of tin, with a bulbo-cylindrical glass, and cost, by the quantity, about $9 per dozen.

BURNERS.

The *burner* is the most important part of the lamp with regard to the light produced, the power and brilliancy of which depend upon the proper combustion of the vapor of the oil, and this combustion depends upon the supply of oil and air to the flame, which is regulated (including wick) by the burner, and it also determines the shape and volume of the flame, and, very much, its character with respect to odor and smoke.

The conditions of a good burner are that it takes a suitable wick for the oil used, compresses, raises, and lowers it *evenly*, creates two or more currents of air of such *force* and *direction* that oxygen will be adequately and properly supplied to the flame, and is strong, durable, and easy of manipulation for trimming wicks, cleaning, attaching, and detaching chimneys. For heavy oils in cold weather, the more it heats them the better; but it is the reverse with kerosene oils not of the heavy grades. Its construction should be such as to reduce the possibility of igniting the oil or vapor in the fount by its flame to the minimum.

They are divided into the two classes of round (argand) and flat wick burners. Of the first class, the sizes ordinarily used are Nos. 1 and 2; of the second class, 0, A, and B. No. 2 and B are the largest of the sizes here given, the first being seven-eighths and one inch in diameter; the other seven-eighths of an inch wide.

There is a great variety of patterns, mostly in the second class, each one claiming some special merit, and being generally patented.

Some thirty-odd burners have been carefully tested by the Board.

The shape of the flames with the argands differed little, while with the flat wicks there were a variety of shapes, including *fish-tail*, *bat-wing*, *fan*, *crescent-top*, *rectangular*, with modifications of these forms. The fish-tail and crescent-top varieties smoked and frequently broke the chimneys, although great care was taken in trimming the wicks, regulating the light, and using chimneys specially adapted in form to

the burners under trial. In several cases the light was good, with a well-shaped, uniform flame giving little or no perceptible smoke or odor, while some failed to burn satisfactorily kerosene oil of 200° or a higher grade. Different grades of kerosene, also sperm and lard oils, were tried. The experiments with sperm and lard oil proved that the burners for kerosene were unsuitable for these oils, and that the light, when they were tried with these burners, soon went out. Lard and sperm oils require the flame near them, but kerosene more distant, about 2 inches. With the animal oils tested were used the lard-oil lamps for lighting the grounds at Governor's Island. For carbon oils, several of the burners tried, most suitable for army use in the judgment of the Board, were selected, with which were made additional trials.

The grades of oils taken for experiments were the best quality of winter strained sperm and lard and the commercial kerosene of 150°, 200°, and 300° F. *fire-test*, including those of 15° to 20° F. higher or lower market grades. No. 2 round and B flat wick burners were used in the experiments noted below. The "standard candle" is taken as the unit of power in the photometrical tests.

The following data gives the general results of the Board's experiments, omitting the details in each of the many tests made and small decimal fractions:

Oils.	Burners.	Average candle power.	Consumption per hour.
			Ounces.
Sperm	Round 1 inch	14.32	2.50
Lard	do	18.24	2.25
K. 150°	Round seven-eighths inch.	18.39	2.48
K. 150°	Flat B	11.86	1.68
K. 200°	Round seven-eighths inch.	17.19	1.93
K. 200°	Flat B	11.52	1.51
K. 300°	do	8.74	1.33
K. 300°	Round*		

*Not tried with this burner.

The Manhattan, Monarch, Richmond, Sun-hinge, Eastlake, and Dual, flat-wick burners selected by the Board, gave average results, to wit:

Oils, K. 150° and 200°; average candle power, 12.98; consumption per hour, 1.62 ounces.

Funck's seven-eighths, and the "Cleveland Non-explosive Lamp Company's" 1-inch round burners, the best ones tried of this class, showed the following average results:

Oils, K. 150° and 200°; average candle power, 18.77; consumption per hour, 1.96 ounces.

The candle power of the round wicks, as compared with the flat ones with the same oils, with the burners selected, is seen to be 144.6 per cent., and consumption per hour nearly 121 per cent. With sperm, lard, and the heavy kerosene oils, in capillary lamps, the light gradually lessens in power as the oil is consumed.

The Funck seven-eighths-inch argand burner gave greater candle power than any other one of the same or 1-*inch* size tried, with an

average consumption of about $1\frac{3}{4}$ ounces per hour. It, and the Manhattan, gave the most *steady* and *uniform* light of any of the round and flat wick burners, although some of the latter exceeded in power that of the Manhattan. These two, with reflectors, gave, respectively, 74.8 and 63 candle power, as the maximum result of several trials. The experiments proved that with suitable reflectors, properly adjusted to put the flame in their foci, the power of the light is increased very much; that it can be diffused at different angles, or reflected in a beam, according to its distance from the reflector, and that the use of adjustable reflectors will increase much its utility for general use in the service.

With the same kind of oil, the round-wick burners diffuse equally the light in all directions, while with the flat-wick class it is about five-twelfths less edgewise than in the broadwise direction.

WICKS.

With illuminating oils, the character of the flame with regard to volume and brilliancy, as well as the consumption of oil, depend much upon the kind and quality of the wick used.

To insure a good light, the wick must regularly and adequately supply the flame with the oil needed for combustion.

Non-combustible, chemical, and the ordinary cotton wicks are used; the first two named are disregarded from further consideration as being unsuitable for the service. Cotton wicks should be made of the "long staple," be free from knots and bunches, and soft to the touch; they are made round and flat, thick and thin; the threads should be loosely twisted or plaited, and the wicks have a light or thin woof.

In capillary lamps the thick wicks are considered the best for sperm, lard, and the 300° or heavy grades of kerosene oils. With the 200° and lighter grades of kerosene, the comparatively thin wicks, if of the proper quality, have shown the best results; they are preferable with the argand burners and in the constant level lamps.

Wicks, when new and first used, should be cut carefully and evenly with the top of the wick-tube, and generally the corners clipped off a *trifle*. Afterwards they usually require little trimming with scissors, it being only necessary to lower them in the tube and strike or rub off the carbonized tops evenly therewith.

If more care were taken in selecting suitable wicks and trimming them properly than is the case generally, the result would be a better light, with less odor and smoke from the flame.

The Fletcher Manufacturing Company, of Providence, R. I., has a high reputation for making excellent lamp-wicks.

CHIMNEYS.

There are a variety of forms of lamp chimneys, some of which are designed for particular kinds of burners, and, with respect to the draft created, form a part of them; others are shaped for general application; they are attached to the burner by means of screws, clasps, and springs, the latter being usually the most convenient.

If the chimney is quickly and unequally heated it frequently breaks—a cause of annoyance and expense; hence its form should be adapted to the shape of the flame; currents of cool air or water-spray striking hot chimneys are very apt to break them. Many of those sold in the market are of inferior quality. It is important to select those of good quality and suitable shapes.

Those made of the best quality of flint glass, and annealed by immersion in a hot oil bath, which cost from 50 to 75 per cent. more than the ordinary quality, but save in loss from breakage about 700 per cent., are preferable, and are the most economical.

Messrs. E. de La Chapelle & Co., at the La Bastie Glass Works, Brooklyn, N. Y., which place members of the Board visited, have made the annealed quality mentioned.

At these works the severe tests of rapidly and unequally heating these chimneys, and then sprinkling cold water upon them, as also of driving nails with, and striking them upon a wooden bench forcibly, were made, which tests they stood remarkably well, seldom breaking, except after repeated and persistent attempts.

This company has supplied in quantity the Light-House Department with argand chimneys.

It is reported that another firm in New York made an excellent quality of annealed chimney, but the Board has no detailed information thereof.

The following table shows the relative cost, candle power, and weight of the several materials considered by the Board for purposes of illumination, and will serve as a basis for approximately estimating the cost of light required:*

Materials.	Cost per gallon.	Candle power per hour.		Cost of 100.	Approximate candle power estimated for rooms of different length, with hourly cost of light.				Weight of material for 100 candle power.
		Round wick.	Flat wick.		75 to 100 feet, 60 candle power.	50 to 75 feet, 50 candle power.	30 to 50 feet, 40 candle power.	20 to 30 feet, 25 candle power.	
OILS.				*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Cents.*	*Ozs.*
175 to 200 K	$0 20	1,317	....	.0151	.0090	.0075	.0060	.0037	8
175 to 200 K	20	.....	998	.020	.012	.0100	.008	.0050	10.6
Sperm	1 05	733	.... ..	.1428	.0856	.0714	.0571	.0357	16
Lard	60	1,037	.....	.0571	.0342	.0285	.0228	.0143	12.24
CANDLES.*	Per lb.								
Adamantine	15	41.7		.357	.214	.178	.142	.089	*Lbs.*
Paraffine	18	58.25		.30	.18	.15	.12	.075	†2.38
Sperm	25	49.6		.50	.30	.25	.20	.125	

* Estimated at one "standard candle" power. † Considered full weight.

Samples of the Funck and Manhattan lamps recommended were especially made for the Board for trial, and are not in market. They can be supplied in quantity at about $33 and $18 per dozen respectively.

* This, with foregoing tables, gives the requisite data for making necessary estimates.

CONCLUSIONS.

Relying on the facts developed by the investigations made, and taking into consideration the general experience with illuminating oils, the Board concludes that the relatively high cost of animal as compared with mineral oils, and the much higher temperature at which they chill and congeal, render them less suitable as an illuminant, and are good reasons why mineral oil, which gives better light, should replace animal oil for lighting public buildings, &c., in the Army. For equally good and sufficient reasons, the use of candles for lighting barracks, &c., should be discontinued, except to a limited extent for special purposes.

The authorized allowance of candles is considered totally insufficient for the purpose of illumination, and were the allowance sufficiently increased to afford adequate light, the cost and inconvenience as compared with that of kerosene oil would justify their rejection. In fact candles, as a source of light, have in these days but a limited application, and are generally superseded by oil lamps, giving more light at less cost. The "candle-holder," with its reflector, on account of the objection stated, is believed to be unsuitable for general use in the Army, but may serve as an auxiliary light for special purposes.

Taking into consideration the quality, quantity, and economy of the light it produces, good kerosene oil is unquestionably the best material for purposes of general illumination in the Army. It is in use on steamships and railroad cars, in the Light-House Department and Navy, and generally throughout the whole country even where gas is available, and as a source of light has no competitor in the domestic economy of the people. That it has not supplanted candles in the Army is no doubt partly due to the reluctance with which we set aside any means or appliance long in use, but chiefly, it is thought, because of the accidents to life and property which accompanied the introduction of kerosene oil and kept pace with the first years of its consumption. The progress of science and the demands of the public have so stimulated investigation and invention, and pointed out the dangers to be avoided, that it would be as absurd to abandon the use of mineral oils at the present day, on account of the accidents which sometimes occur by the careless use of inferior qualities, as it would be to interdict the use of steam, gunpowder, or even gas, because they too contribute to the annual list of casualties when improperly or ignorantly applied. Setting aside, then, the danger of accident as an objection less real than imaginary, a due appreciation of the necessity of suitable, economical, and brilliant light in the barracks, guard houses, and hospitals of our soldiers, demands that something take the place of candles, and it is the irresistible conclusion of the Board, based upon a due consideration of all the information it has obtained, that mineral oil of suitable quality is the only substitute which will satisfactorily answer the purpose.

In discussing this subject, the Board has not overlooked the importance of good eyesight in relation to target practice in the service and the use of fire-arms generally. No superiority in markmanship can be expected unless the vision is preserved, and nothing will do more to preserve it than a sufficient supply of good, steady light. When the light is insufficient or of poor quality, or both, the muscles of the eye are strained to their utmost to produce a power of accommodation to enable one to read, write, or even distinguish objects at but a short distance. This strain cannot be kept up for any length of time or frequently incurred without producing great damage to the vision. The muscles refuse to respond to the nervous influence, and we have weakness of vision, double vision, short sight, paralysis of the muscles of the eyes, and even total blindness as the resultants—thus destroying the usefulness of the soldier and the man.

There is a constant and increasing demand from the soldiers for more and better light than is now furnished, and to meet this demand the custom prevails of purchasing oils from the company funds and by individual contributions. Thus the rations and pay of the men are taxed for what it seems to the Board is an absolute necessity which the generosity of the Government should supply.

In regard to lamps, burners, chimneys, &c., the Board is of the opinion that "constant level" metallic lamps, with the round or flat wick burners, are the most suitable for army use, for reasons previously given and because they virtually eliminate the danger of accidents. The round-wick burner, with an inconsiderable increase in consumption, gives more light equally diffused than the flat-wick burner, and is, therefore, preferable for barrack rooms of large size. In rooms of ordinary size the flat wick, it is thought, may give satisfactory results, burning somewhat less oil. Patterns which can be used either as bracket, table, or pendent lamps will, it is believed, meet the wants of the service in all respects. The Board is of the opinion that the saving to the Government will in a short time more than offset the expense incurred in procuring the lamps recommended. The subject of transporting and storing kerosene oil has been fully considered by the Board, which has embodied in its report the data bearing on this subject. It is the custom of commerce to transport the oil both in cases and barrels, and it is reported that the leakage when shipped in barrels is so inconsiderable as to be left out of consideration in the trade. Posts in the immediate vicinity of places where the oil is purchased may be supplied either in cases or barrels, while to posts remote from main lines of transportation it would be, perhaps, advisable to transport the oil in cases.

Objections may be made to transporting and storing kerosene oil with other articles of the subsistence department, on the ground that it may impart a disagreeable odor or flavor to certain stores which easily absorb air and moisture.

This, perhaps, might be the case with light oils or naphtha, but it is thought not with the grade of oils recommended.

In conclusion, the Board makes the following

RECOMMENDATIONS.

Oils.—That kerosene oil with a flash-point of not less than 135° F., in closed cup, be adopted for purposes of general illumination in the Army. That verified samples, purchased for the purpose, be carefully tested, pyrometrically and otherwise, by the Government's special inspector, and that it be shipped in barrels or cases, as may be considered most convenient and economical to the Government.

Transportation.—That not more than a three months' stock of oil be shipped at one time to posts which can receive their supplies quarterly or oftener, and that, when the cost of transportation justifies it, the barrels and cases in which the oil is shipped be returned to the vender for refilling.

Lamps.—That metallic "constant level" lamps of the Funck and Manhattan patterns, with round or flat wick burners, arranged so that they can be used with reflectors or without, and either as bracket, stand, or pendent lamps, be adopted for general use—samples with improvements suggested by the Board to be submitted.

2d. That the Cleveland Non-Explosive Lamp Company's lamps (samples submitted) are recommended as second in order, and as good and suitable for any use.

3d. That capillary lamps be used to some extent for convenience. That the best quality of burners, wicks, and chimneys, of the kinds mentioned in this report, be supplied.

4th. That adjustable nickel-plated 8-inch concave reflectors of 10-inch radii be furnished for bracket lamps.

5th. That inasmuch as there is a great lack of uniformity in the size and finish of company quarters throughout the Army, the Board is not able to determine the precise number of lamps per company necessary in all cases. For example, more lamps would be necessary in log or adobe quarters, in which the rooms are not ceiled, than in rooms of the same size properly lathed and plastered; but the Board recommends, as an approximate standard of comparison, that each company be supplied with not less than six lamps, and as many more as may be necessary, according to the size and character of the barracks.

Lanterns.—That the tubular lanterns, with "A" and "B" burners, referred to in this report, be adopted for lighting stables, shops, storehouses, guard-rooms, &c.

Candles.—That candles be retained for camp and special use, and that paraffine candles be added to the supply list.

Candle-holder.—That the "candle-holder" with its reflector be furnished to a limited extent for special use and trial.

Department of supply.—That the Subsistence Department furnish the oil, lamps, lanterns, &c., requisite for the light recommended.

Finally, the Board cannot conclude its labors without expressing the deep interest it feels in the subject-matter of this report, which it is believed intimately concerns the mental, moral, and physical improvement of the enlisted men of the Army; and indulges the hope that the foregoing recommendations may receive the favorable consideration of the Government.

The Board having no further business before it, adjourned *sine die.*

N. H. DAVIS,
Inspector-General.
M. D. L. SIMPSON,
Assistant Commissary-General of Subsistence.
JOHN H. JANEWAY,
Surgeon, U. S. A.
J. P. SANGER,
Captain, First Artillery.
CHARLES BIRD,
First Lieutenant, Twenty-third Infantry.

SUPPLEMENT TO REPORT ON LIGHTING COMPANY QUARTERS, ETC.

BY A BOARD OF OFFICERS.

GOVERNOR'S ISLAND,
New York Harbor, January 1, 1880.

SIR: I have the honor to submit this paper as a supplement to the "Report on Lighting Company Quarters, &c., by a Board of Officers," dated November 20, 1879, showing photographs of the sample lamps, &c. (to be forwarded to Washington), taken by direction of the major-general commanding the division, with explanations.

There is added also some new data giving photometric results obtained with these lamps and the adjustable reflectors referred to in the previous report.

Very respectfully,

N. H. DAVIS,
Inspector-General, President of and for the Board.

The ADJUTANT-GENERAL,
Headquarters Military Division of the Atlantic,
Governor's Island, New York Harbor.

EXPLANATIONS.

PLATE 1.

Funck's constant level lamp, Army pattern (circular wick).

PLATE 2.

(Showing parts of the Funck lamp, Army pattern.)

FIGS. 1, 2.—Links to adjust reflector.
FIG. 3.—Shade holder.
4.—Lamp fount (inverted).
5.—Body of lamp.
6.—Wick-holder, with wick.
7.—Wick-holder, with spring prongs.
8.—Chimney gallery, with slotted tube.
9.—Perforated air cone.
10.—Drip cup.
11.—Lamp-shade.
12.—Lamp-chimney.
13.—Reflector, back view.

PLATE 3.

Funck's Capillary lamp (circular wick).

FIG. 1.—Wick-holder, with spring prongs.
2.—Wick-holder and wick (flannel attached).
3.—Lamp, complete.

NOTE.—Burners *in the constant level and capillary lamps* the same.

PLATE 4.

Trent's Automatic constant level lamp, Army Pattern, with Manhattan Burner (flat wick).

FIG. 1.—Base-plate of burner, and wick.
2.—Inner cone.
3.—Outer cone.
4.—Lamp, complete.
5, 6.—Links to adjust reflector.

PLATE 5.

Walton's Patent Reflector Candlestick, complete and in parts.

FIG. 1.—Candle tube.
2.—Base-plate.
3.—Parabolic reflector, without chimney.
4.—Socket joint of candle tube.
5.—Spiral spring to push up candle.
6.—Candlestick, complete.
7.—Parabolic reflector, with chimney and glass front.
8.—Cap-piece of candle tube.

PLATE 6.

Tubular Lanterns.

FIG. 1.—Improved Tubular Lantern, complete.
2.—Wick of Improved Tubular Lantern.
3.—Side (or bracket) Tubular Lantern, complete.
4.—Wick of Side Tubular Lantern.

PLATE 1.

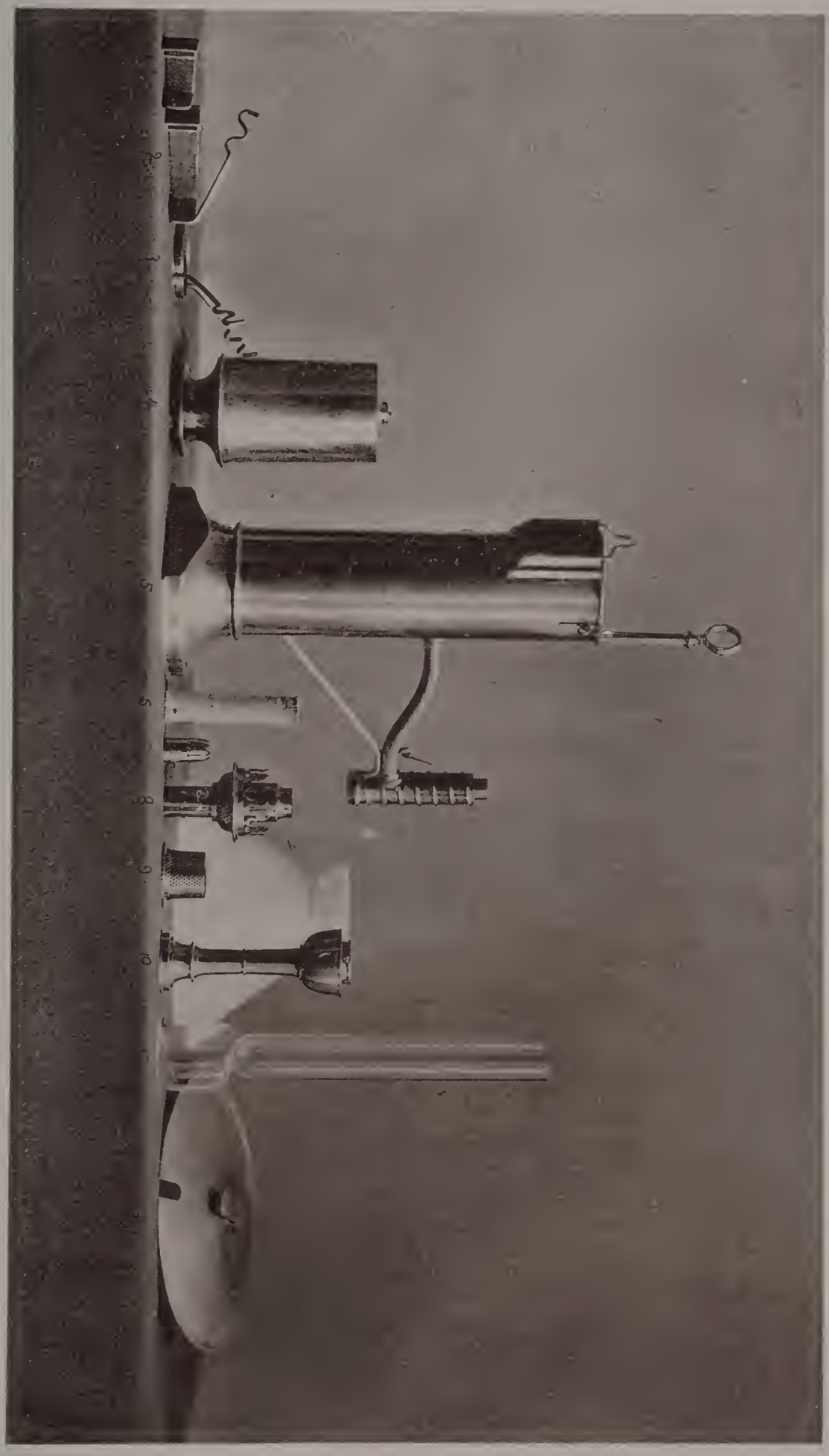


PLATE 2.

PLATE 3.

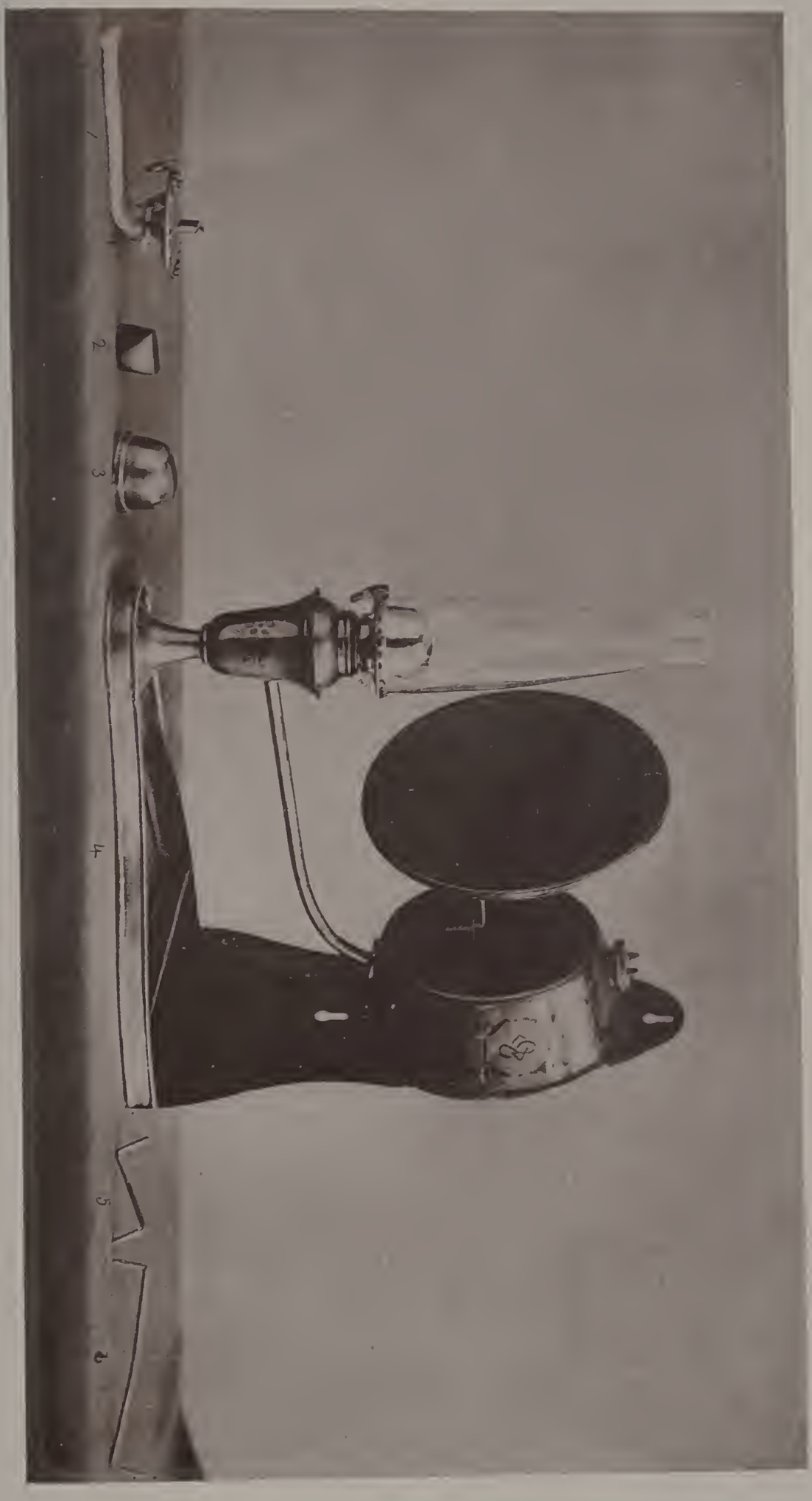


PLATE 4.

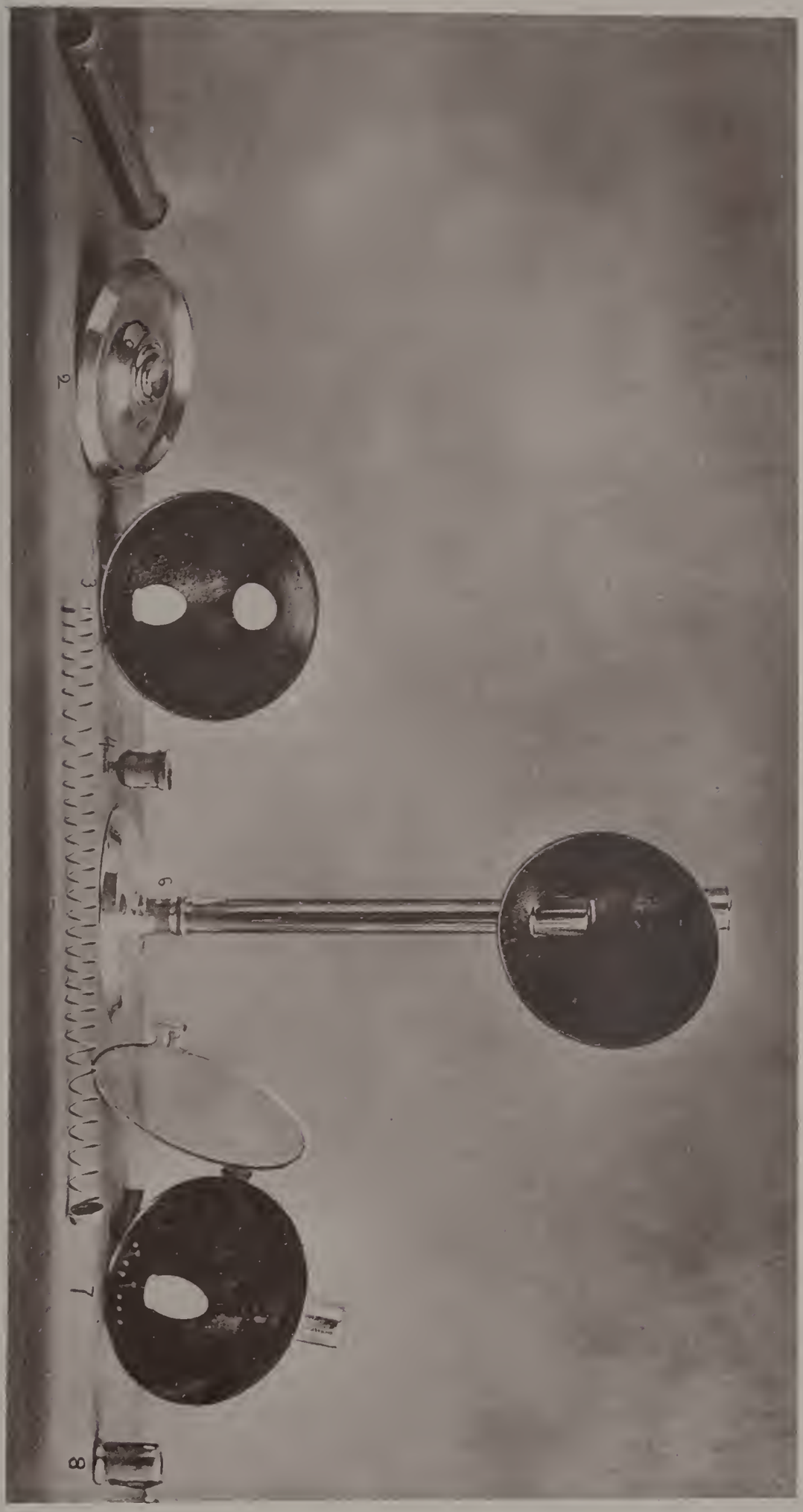


PLATE 5.

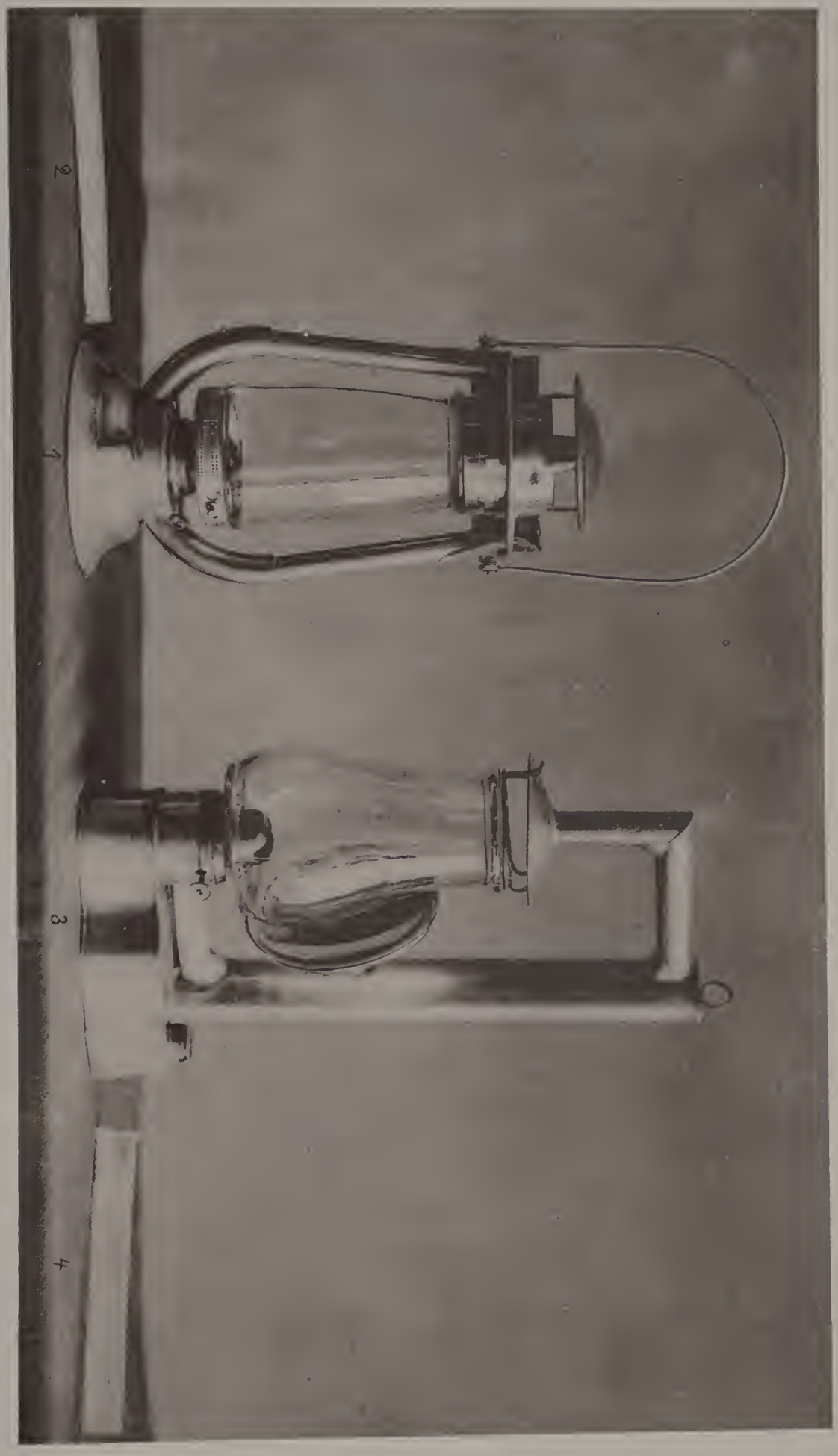
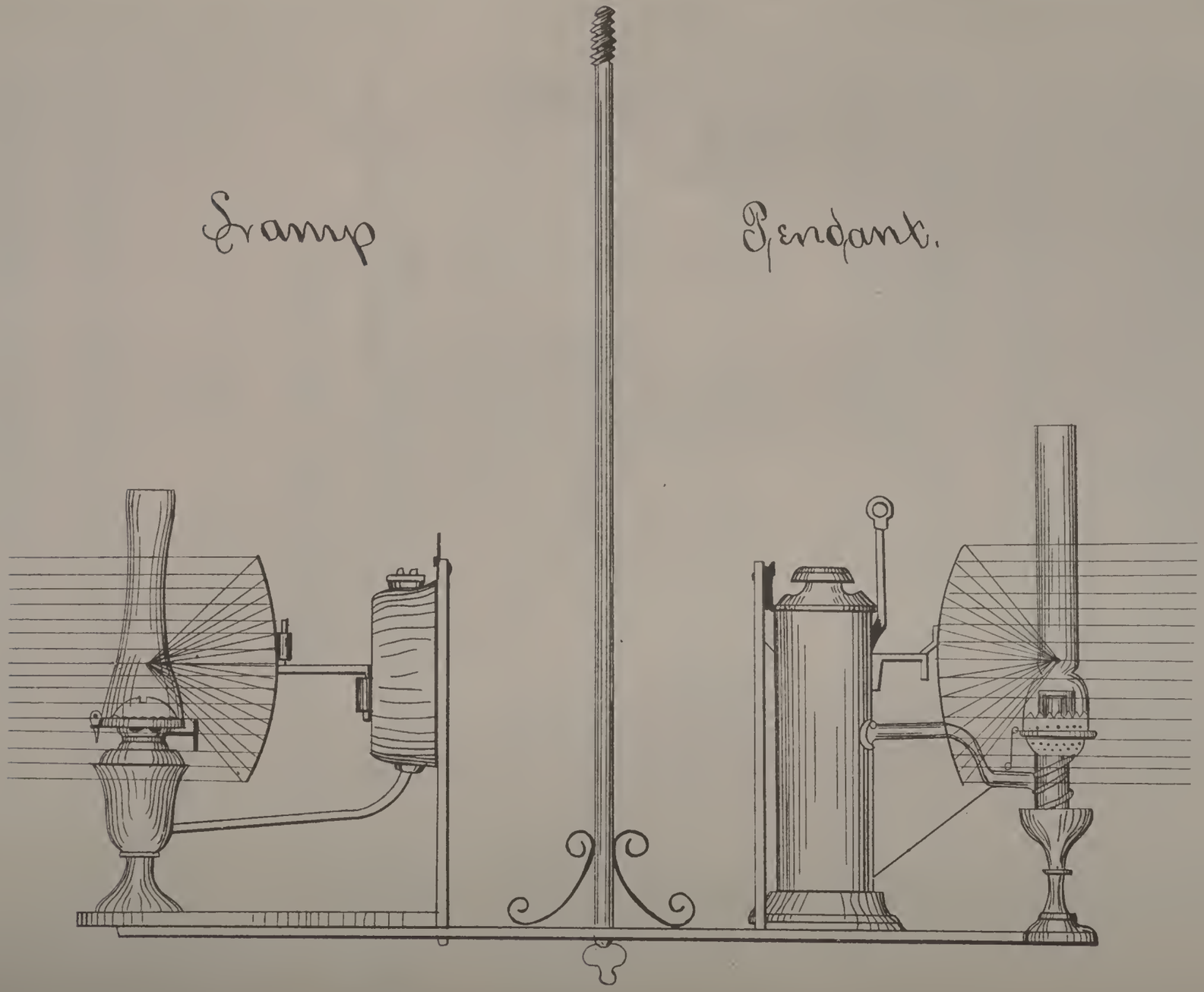


PLATE 6.

Lamp Pendant.



Scale 1½ inch to 1 foot –

New Data.

Funck's constant level lamp, Army pattern, gave with the new 8-inch concave spherical reflector of 10-inch radius, adjusted with approximate accuracy for casting a beam of light, 360 candles power.

The Trent Automatic constant level lamp, Army pattern, gave with like reflector and adjustment, 92 candles power.

Note.—To obtain the maximum candle power of the lamp, with this reflector its center should be accurately adjusted at 4 13-16 inches from the center of the flame, horizontally measured.

Subsequent experiments with this reflector so adjusted, gave the remarkable results, to wit:

Funck lamp, 500 candles power.

Trent lamp, 223 candles power.

REPORT ON MINERAL OILS AND LAMPS.

Proceedings of a Board of Officers convened pursuant to the following instructions of the Quartermaster-General, United States Army:

War Department, Quartermaster-General's Office,
Washington, D. C., August 12, 1880.

A Board of Officers, to consist of Lieutenant-Colonels Holabird, Hodges, and Major Moore, is constituted, to whom all the papers on this subject are referred, with instructions to prepare estimates of the expenditure required by the introduction throughout the Army of mineral oil and lamps for illumination of barrack, hospitals, and guard-houses, to which the Inspector-General recommends that for the present the supply of mineral oils by the United States be limited.

Schools and chapels, however, should be included in estimate. The estimate should provide from Incidental Expenses appropriation for purchase of oil and lamps.

From Barracks and Quarters for stationary iron tanks for its storage and preservation.

Army Transportation for its transportation generally.

Transportation to be in barrels, which should be returned whenever the cost of transportation to the refinery will not exceed the value of the barrel.

A sufficient quantity of oil to be transported from time to time in metallic cans to provide for the storage in officers' quarters of the oil to be purchased by them from time to time.

As it is evident that the present appropriation will not justify the attempt to at once supply this oil to all military posts, it is desired that a list of posts be prepared in which it may be introduced on trial.

Hereafter, if the result is satisfactory, and Congress grants the necessary appropriation, its use can be extended to others.

The estimate for regular supplies for the next fiscal year should provide for proper lighting of barracks and quarters by the Quartermaster's Department, should the Secretary of War determine to transfer this work from the Commissary Department to the Quartermaster's Department.

The Board met pursuant to the above instructions, August 16, 1880. Present, all the members.

The Board held informal meetings until August 20, when conclusions

were reached as to the quantity and quality of oil, the number and kind of lamps for barracks, guard-houses, chapels, school-houses, &c., at all military posts throughout the Army.

The Board examined the letters and printed data received from the headquarters Military Division of the Atlantic, and a report on lighting company quarters, by a board of Army officers, convened at Governor's Island, New York Harbor, November 20, 1879.

The practical tests made by this Board of Officers referred to, with the aid of an expert, to examine the various kinds and qualities of oils submitted, their flash point, fire test Fahrenheit, average candle power, consumption per hour, &c., were so thorough and exhaustive in detail that the Board concurs in their recommendations, believing that until it is ascertained by actual trial of both lamps and oil at the military posts throughout the Army, that no better standard than that determined by said Board can be suggested.

RECOMMENDATIONS.

The Board is of the opinion that kerosene oil with a flash point of not less than 135° Fah., in closed cups, be adopted for the purpose of trial at all military posts in the United States.

Each company to be furnished with six lamps.

The estimated time for the lamps in barracks to burn is four hours per night.

The quantity of oil to be consumed for each lamp is estimated at 2 ounces per hour, or 8 ounces per night.

The six lamps for a company will require 48 ounces of oil per night.

The average weight of kerosene oil per gallon of 110° to 150° is $6\frac{1}{2}$ pounds, or 104 ounces, upon which the following estimate is based:

There are in the Army 430 companies of all arms of the service, and 170 posts, including arsenals.

The estimated quantity of oil to be consumed by the 430 companies at the given rate is 72,438 gallons, to which the Board deems it advisable to add 20 per cent. for guard-houses, chapels, school-houses, and leakage, &c., making the total number of gallons 86,925, which, at 20 cents per gallon, will cost $17,385.

The price per gallon at which the oil is estimated is believed to be sufficient to include the cost of cans securely boxed.

The stationary iron tanks for its storage and preservation with capacity for 1,000 gallons will cost $130 each.

It is not known to the board whether it is designed by the Quartermaster-General to furnish tanks for all the posts, or what number of posts; therefore no estimate of the total cost is stated.

The Board convened at New York Harbor, referred to in these proceedings, having examined and experimented with a great variety of lamps in order to ascertain those well adapted for Army use, find that among the most satisfactory pattern tried, the Funck lamp with seven-

eighths-inch argand burner, gave greater candle power than any other of the same, or one-inch size tried, with an average consumption of about 1¾ ounces of oil per hour.

The Board, recognizing the careful and exhaustive trials made by the New York Board, recommends the Funck lamp with seven-eighths-inch argand burner, with suitable reflectors, to be supplied to the military posts in the Army.

The 430 companies furnished with 6 lamps to a company will require 2,580 lamps.

The Board recommends that 10 additional lamps be supplied each post for guard-house, chapel, &c., making for the 170 posts 1,700 lamps to be added to the number 2,580, or a total of 4,280 lamps.

The cost of each lamp is $2.75, or $33 per dozen.

At this rate the requisite number of lamps for the purpose stated will cost $11,770, to which add the cost of oil, $17,385; it will make a grand total of $29,155 for the purchase of oil and lamps for all posts in the United States Army.

There being no other business before the Board, it adjourned *sine die*.

S. B. HOLABIRD,
Deputy Quartermaster-General, U. S. A.
HENRY C. HODGES,
Deputy Quartermaster-General, U. S. A.
JAS. M. MOORE,
Major and Quartermaster, U. S. A.

ARMY LAMPS.

PROCEEDINGS OF BOARD OF OFFICERS, DRAWINGS, NOTES, ETC.

ARMY BUILDING,
New York, N. Y., December 7, 1883.

GENERAL: The Board of Officers convened by Par. IV, Special Order 127, War Department, Adjutant-General's Office, June 4, 1883, having completed the duties assigned to it, and having forwarded their report to you, has this day adjourned *sine die*.

The lamps, burners, &c., examined by the Board will be kept by Lieutenant Day, recorder of the Board, until instructions as to their disposition are received.

Respectfully, your obedient servant,

R. JONES,
Lieut. Col., A. I. G.

To
The ADJUTANT-GENERAL, UNITED STATES ARMY,
War Department, Washington, D. C.

ARMY BUILDING,
New York City, December 7, 1883.

SIR: I have the honor to transmit herewith the report of the Board on Lamps, instituted by Special Orders No. 127, from your office, dated June 4, 1883.

In the same mail and accompanying this I also send a sheet with two tables embracing the results of all tests made, also a package of drawings and another containing the descriptions of the lamps tested; in all, four packages.

Very respectfully, your obedient servant,

S. A. DAY,
First Lieutenant Fifth Artillery, U. S. A., Recorder.

ADJUTANT-GENERAL, UNITED STATES ARMY,
Washington, D. C.

[First indorsement.]

WAR DEPARTMENT,
ADJUTANT-GENERAL'S OFFICE,
Washington, December 11, 1883.

Respectfully referred to the Quartermaster-General for remark.

By order of the Secretary of War.

R. C. DRUM,
Adjutant-General.

NEW YORK, N. Y.,
December 7, 1883.

GENERAL: The undersigned, members of a Board of Officers convened by virtue of the following orders, to wit:

SPECIAL ORDERS No. 127.

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, June 4, 1883.

[Extract.]

* * * * * * *

4. A Board of Officers, to consist of Lieut. Col. Roger Jones, Assistant Inspector-General; Maj. David Perry, Sixth Cavalry; Capt. Joshua A. Fessenden, Fifth Artillery; First Lieut. Selden A. Day, Fifth Artillery, Recorder, is appointed, to meet at the Army Building, New York City, on the 11th instant, or as soon thereafter as practicable, for the purpose of examining and reporting upon the merits of certain lamps designed by J. F. Donnell & Co., of New York City, with a view of supplying the Army therewith.

The journey of Lieutenant Day, from his present station to New York City and return, is necessary for the public service.

* * * * * * *

By command of General Sherman.

R. C. DRUM,
Adjutant-General.

Official.

M. BARBER,
Assistant Adjutant-General.

respectfully report, that having assembled at an early day as practicable, proceeded at once to examine the lamps referred to, and while engaged in giving them practical tests, by using some of them in their own quarters, and causing others to be used by soldiers in barracks at Forts Columbus and Hamilton, invited under authority of the Honorable Secretary of War, communicated in a letter from your office dated July 19, 1883, other manufacturers to submit for trial any lamps they might desire to have tested, with a view of supplying them to the Army.

At an early stage of our proceedings it became apparent it would be necessary to do much more than merely experiment with the lamps, by a simple trial of them in barracks, however protracted the trial might be, and accordingly, after a full consideration of the subject, it was deemed expedient to determine the candle-power, the oil consumed per hour, and the oil consumed per candle per hour of the lamps brought before us.

Having qualified himself for the work in hand, and having constructed the scale, apparatus, and other things essential to conducting the experiments which were deemed necessary to a thorough investigation of the subject committed to the Board, Lieutenant Day, in our presence, made the experiment in every case, with such assistance as the other members of the Board could, individually or collectively, give him.

The results of these numerous tests are embodied in the exhibit or table herewith appended.

The number of burners tested, it will be seen from the table, is fifty-four, and in addition one torch for outside illumination.

These experiments, conducted over a period of three months, have been made with extreme care, and, we believe, show very faithfully the candle-power, the consumption of oil per hour, and also the consumption of oil per hour per candle-power of every burner reported on.

Recognizing that the value of this table would be greatly enhanced by a description of the lamps and burners, so as to convey, if not an accurate, at least some general idea of them, a description of them has been prepared and is attached as an appendix to this report, immediately after the table.

It is probable that a large majority of the principal burners at present in use have been brought before and tested by the Board, although there must be many modifications of them of which we have no knowledge.

It was evident, from the number and variety of burners that were presented by inventors or their agents, that great improvements have been made during the last few years in the devices for burning kerosene oil for illuminating, as well as for other purposes, and it would seem that almost every situation and condition of things, where light from lamps or torches is needed, had been provided for.

CONCLUSIONS.

After careful tests extending, as already stated, over a period of several months, and after a full consideration of the wants and special requirements of the *service*, we have come to the following conclusions:

BURNERS.

First. That the burner known as the "Mitrailleuse burner," so called from its resemblance to a miniature multibarrel machine gun, composed of a number of tubes carrying the wicks, is most suitable for *Army purposes*, not only on account of its *high record* as to candle power, in this particular surpassing all others, and economy in consumption of oil, but also because of its special adaptability for burning, from an ordinary font, the exceptionally heavy and high grade of kerosene oil supplied by the Quartermaster's Department, thus dispensing with the necessity of lamps constructed on the constant level principle, which is the characteristic of all lamps of the student pattern, as also of the lamp now used in the Army, it having been found that the capillarity of the wicks was sufficiently strong to draw this heavy oil high enough above its natural level to empty an ordinary lamp font.

Of these "Mitrailleuse burners" three sizes were submitted and tested, one with ten wicks, a second with twelve wicks, and a third with sixteen wicks.

The ten-wick burner is $1\frac{1}{4}$ inches in diameter, and, being adapted to any font having a common or B collar, is recommended for use where these fonts and fixtures are already on hand.

The second or twelve-wick burner, however, on account of its greater light giving power and economy, is the one we recommend for adoption and use in barracks, in all cases where an ordinary font with the B collar is not already provided.

The largest size, or sixteen-wick burner, gives, as will be seen from the table, light equal to thirty-two candles, and where such a strong, brilliant light is needed it must commend itself to favor, but, for soldier's barracks, it is not, in our judgment, as desirable as the twelve-wick burner.

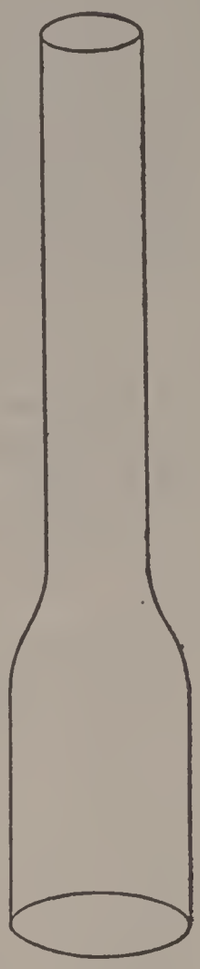
Two forms of the "Mitrailleuse burner" were submitted to the Board, differing but slightly in their construction, the first in order in the table, having the ratchet for raising and lowering the carriage containing the tubes and wicks passing through its center; the other with the ratchet on the side.

The latter, known as the Donnell pattern, also differs from the center ratchet pattern in having a stop between two of the tubes, thus preventing the inner half-tubes with beaks for holding the wicks from being carried so high as to expose them to the action of, and consequent danger of injury by, the flame.

In the Donnell pattern the wick tubes pass through a plate at the top, while in the center-ratchet pattern this plate embraces only the outer half of their circumferences.

CHIMNEY.

The chimney required for these burners is of a simple, durable form, as shown in the margin, and when properly tempered and used with care will not readily break under the usual variations of temperature to which it is of necessity subjected.



Our supplementary tests show that for an equal quantity of oil consumed there is no appreciable difference in the light-giving power of these two burners.

These burners, it is thought, are at present imported; the center-ratchet pattern having been submitted by A. H. Hogg, of No. 11 Murray street, and the side-rachet pattern by J. F. Donnell & Co., No. 822 Broadway, both of this city.

RECOMMENDATIONS.

It is claimed for the latter that it embraces all the latest improvements, and as it will probably be found best suited for Army purposes, *its adoption is recommended by the Board.*

If, however, from any cause it should be impracticable to provide the Army with the Donnell mitrailleuse burner, the Board *recommends* as a *second* choice the burner known as the Oxford dual, No. 50, in the table, manufactured by the Plume and Atwood Manufacturing Company, No. 18 Murray street, New York.

FIXTURES.

A great variety of fixtures were examined by the Board—excellent forms for ordinary and domestic purposes having been submitted by—

Messrs. J. F. Donnell & Co.

The Manhattan Brass Company.

The Gleason Manufacturing Company and the Ansonia Brass and Copper Company, of New York.

The Cleveland Safety Lamp Company, of Cleveland, Ohio.

The Bridgeport Brass Company, of Bridgeport, Conn.

J. Hollings & Co., of Boston, Mass., and others.

None of them, however, seemed to fully meet the special requirements of the service, and it was therefore thought best to combine certain features found in different exhibits and recommend the bracket and pendant shown in the accompanying drawings, with specifications for their construction, &c.

PENDANT.

The *pendant* to be of one-half inch brass tubing, in harp-form, and to hold but one lamp.

The *cup*, to hold the font, to be of spun brass with open-work sides, coming well up around it, as shown in drawings, with a female screw in

base, so as to fit on an ordinary gas-fixture, and to be similar to and interchangeable with the cup on the bracket.

BRACKET.

The *bracket* to be of five-eighths-inch brass tubing, with wall plate having four screws, as shown in drawing, one of the connecting pinions to be fitted with screw and nut to keep the projection in place when struck from below. Cup, font, and burner to be similar to those used in pendant, and interchangeable.

FONT.

The *font* to be of heavy glass, of the pattern known as the Gordon font, as shown in the drawings, the base of the font to be broad enough to permit it being used on a table with safety.

While the lamps and fixtures recommended for adoption may be used with shades, globes, or reflectors, it is not recommended that these articles be provided for issue, though it undoubtedly would be a great convenience if they should be kept in store for sale.

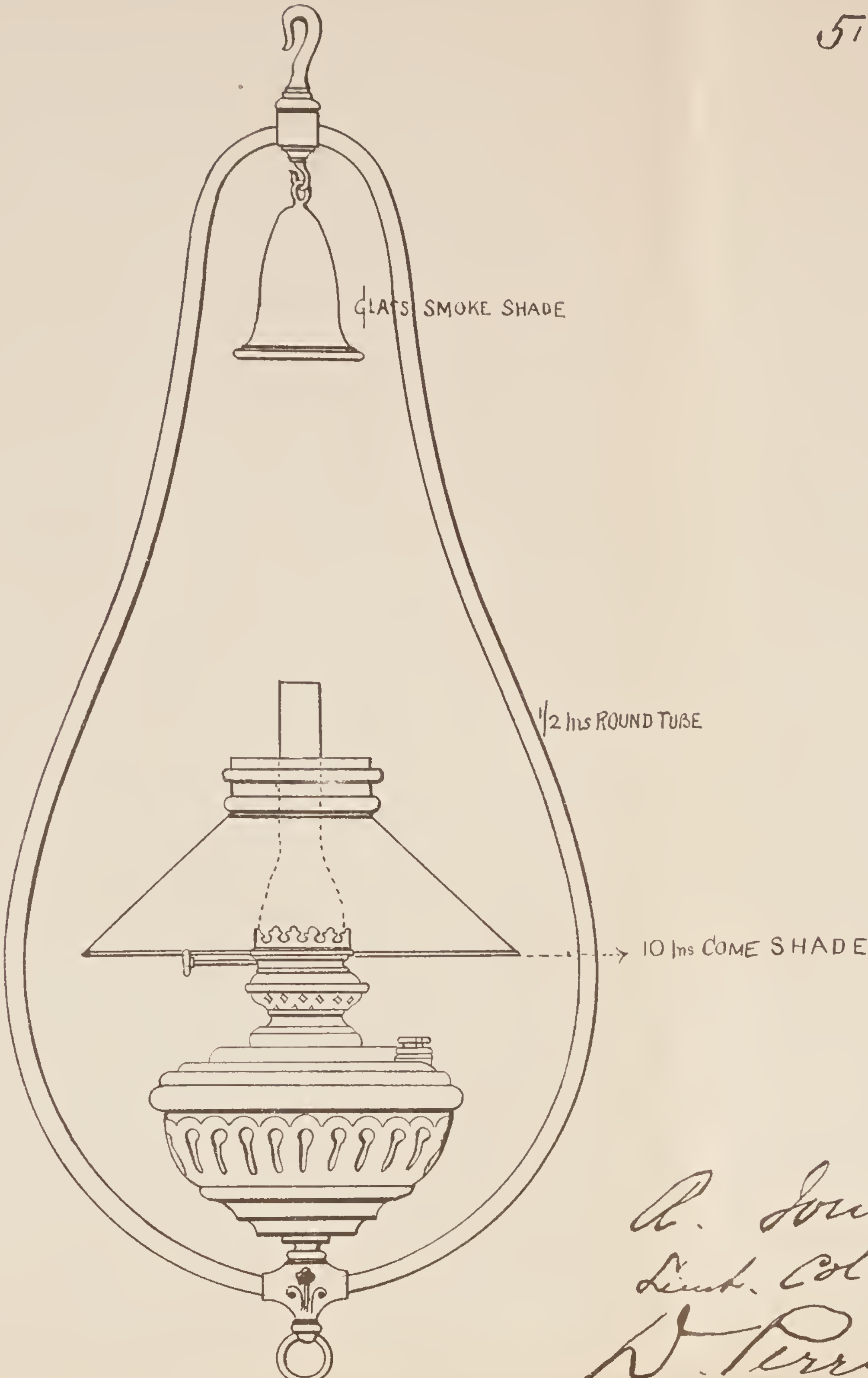
Respectfully submitted.

R. JONES,
Lieutenant-Colonel, Acting Inspector-General.
D. PERRY,
Major, Sixth Cavalry.
J. A. FESSENDEN,
Captain, Fifth Artillery.
S. A. DAY,
First Lieutenant, Fifth Artillery, U. S. A., Recorder.

The ADJUTANT-GENERAL, UNITED STATES ARMY,
Washington, D. C.

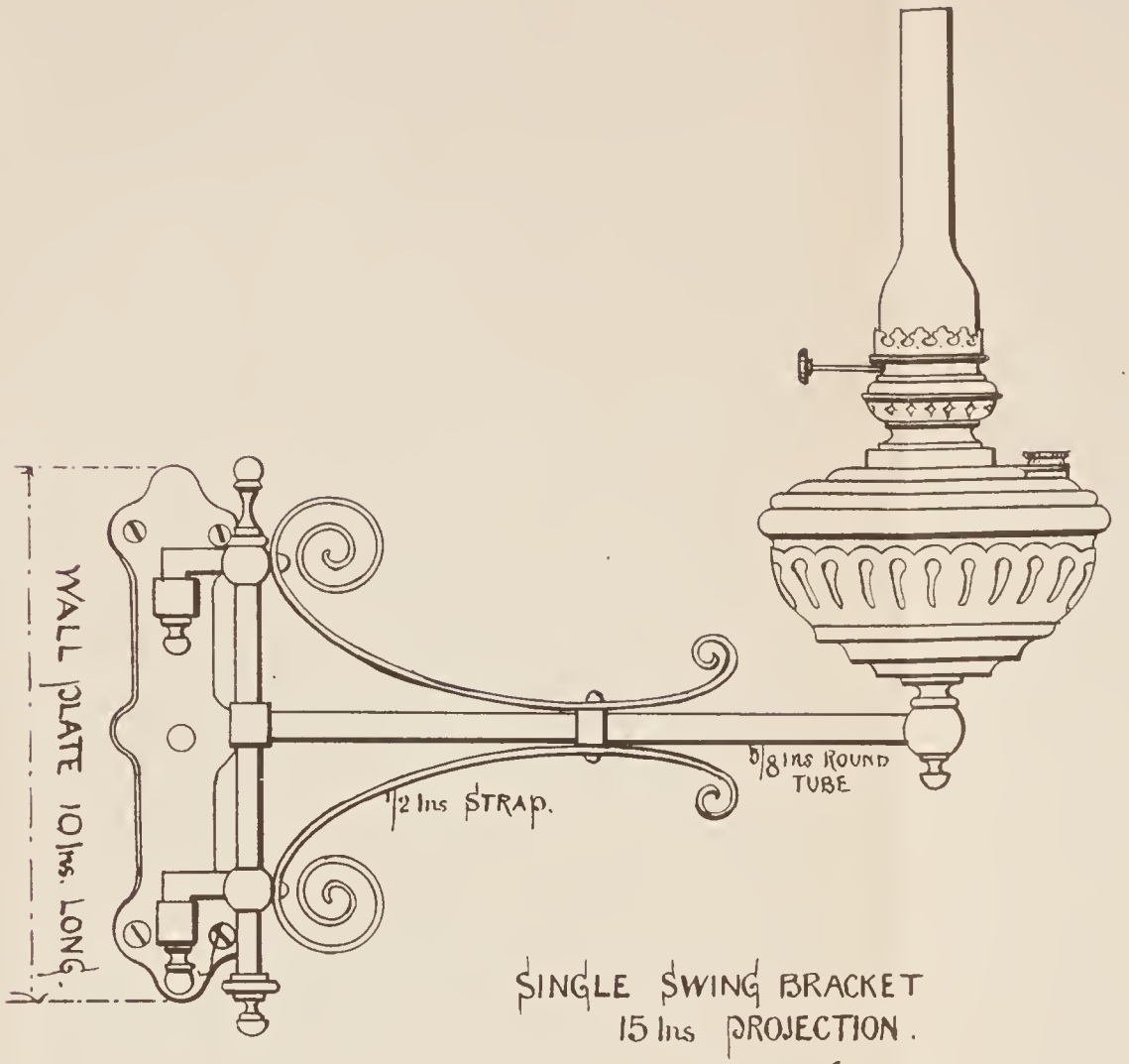
4

5123 a.g.o. 1883



1 LIGHT PENDANT
13 Ins SPREAD
30 Ins LONG

R. Jones
Lieut. Col. A. I. G.
D. Perry
Maj. 6th Cav.
J. H. Tressenbury
Capt. 5th Arty.
E. A. Day
1st Lt. 5 Arty. [illegible]
Receiver.



SINGLE SWING BRACKET
15 Ins PROJECTION.

R. Jones.
Lieut. Col. A. I. G.

V. Perry
Maj. 6th Cav.

J. M. Frossenden
Capt. 5th Cavalry

Lloyd Perry
1st Lt 5th Cavalry Aide

Recorder

TABLE No. 1.—*Burners tested by Army Board on lamps*, 1883.

No.	Name.	Kind.	Candle power.	Oil consumed per hour.	Oil consumed per hour per candle power.	Approximate cost.	By whom presented.	Manufacturers.	Remarks.
				Oz.	*Oz.*	*Per doz.*			
1	Good Night	⅜-inch flat wick	1.84	.35	.1902	$1 25	The manufacturer	Bridgeport Brass Company, 19 Murray street, New York.	Takes small Sun chimney.
2	Eureka, No. 0	½-inch flat wick	4.03	.75	.1861	90	do	Manhattan Brass Company, cor. First avenue and Twenty-eighth street, New York.	Takes No. 0 Sun chimney.
3	Sun, No. 0	½-inch flat wick	5.22	.75	.1339	90	do	Bridgeport Brass Company, 19 Murray street, New York.	Do.
4	Lincoln, No. 0	½-inch flat wick	5.14	.85	.1654	90	do	do	Do.
5	Eureka, No. 1	⅝-inch flat wick	8.55	1.25	.1462	1 00	do	Manhattan Brass Company	Takes No. 1 Sun chimney.
6	Spring Hinge, No. 1	⅝-inch flat wick	9.30	1.5	.1613	1 40	do	do	Takes No. 1 Lip chimney.
7	Standard, No. 1	⅝-inch flat wick	8.88	1.15	.1295	1 00	do	do	Takes No. 1 Sun chimney.
8	Lincoln, No. 1	⅝-inch flat wick	9	1.26	.1400	1 00	do	Bridgeport Brass Company	Do.
9	Sun, No. 1	⅝-inch flat wick	6.32	1	.1582	1 00	do	do	Do.
10	Safety Pocket	⅝-inch flat wick	1.84	.4	.2174		do	do	Takes no chimney.
11	Cleveland Safety, No. 1.	⅝-inch flat wick	9.91	1.6	.1615	*12 00	S. J. Hogg, 11 Murray street, New York.	Cleveland Manufacturing Company, Cleveland, Ohio.	
12	Silver Light	⅝-inch flat wick	5.68	1.1	.1937	2 75	A. H. Hogg, 11 Murray street.		Takes no chimney.
13	Aladdin, or locomotive hand lamp.	⅝-inch flat wick	2.28	.75	.3289		J. F. Donnell		Do.
14	Leader, No. 1	1-inch flat wick	8.40	1.5	.1785	1 90	The manufacturer	Bridgeport Brass Company	Takes special flat square base chimney.
15	Eureka, No. 2	1-inch flat wick	7.8	1.5	.1923	1 50	do	Manhattan Brass Company	Takes No. 2 Sun chimney.
16	Spring Hinge, No. 2	1-inch flat wick	13.16	1.8	.1368	2 25	do	do	Takes No. 2 Lip chimney.
17	Parlor, No. 2	1-inch flat wick	14.08	1.75	.1243	1 50	do	Bristol Brass and Clock Company.	Takes No. 2 Sun chimney.
18	Standard, No. 2	1-inch flat wick	12.10	1.7	.1404	1 50	do	Manhattan Brass Company	Do.
19	Lincoln, No. 2	1-inch flat wick	10.78	1.7	.1577	1 50	do	Bridgeport Brass Company	Do.
20	Sun, No. 2	1-inch flat wick	12.78	1.75	.1369	1 50	do	do	Do.
21	Excelsior, No. 2	1-inch flat wick, for illuminator.	12.3	1.8	.1463	1 50	do	do	Takes No. 2 Lip, or illuminator.
22	Perfection, No. 2	1-inch flat wick	12.08	1.98	.1639	1 50	S. J. Hogg	Cleveland Manufacturing Company.	Takes No. 2 Sun chimney.
23	Hitchcock	1-inch flat wick	14.6	2.3	.1575	60 00	S. E. May, 11 Murray street.		Takes no chimney; mechanical blast.

TABLE No. 1.—*Burners tested by Army Board on lamps*, 1883—Continued.

No.	Name.	Kind.	Candle power.	Oil consumed per hour.	Oil consumed per hour per candle power.	Approximate cost.	By whom presented.	Manufacturers.	Remarks.
				Oz.	*Oz.*	*Per doz.*			
24	Unique, No. 2	1-inch flat wick	13.16	1.85	.1406	$2 25	The manufacturer	Plume and Atwood Manufacturing Company, 18 Murray street, New York.	Takes No. 2 Lip chimney.
25	do	1-inch flat wick, double thick	13.20	1.75	.1326	2 25	do	do	Do.
26	Sun Hinge, No. 2	1-inch flat wick	11.00	2	.1818	2 25	do	Edward Millor & Co	Do.
27	Hollings, new	1-inch flat wick, triple thick, folded.	8.10	1.9	.2346		do		Takes No. 1 Lip chimney.
28	Pinafore, A	1-inch flat wick	13.97	1.55	.1109	1 90	do	Gleason Manufacturing Company, Houston and Mercer streets, New York.	Takes special flat oval base chimney.
29	Drummond	1-inch flat wick, with feeder	13.09	2	.1528	2 25	do	do	Takes special flat round base chimney.
30	McLewee	1-inch flat wick	14.52	1.75	.1205		do	Hektograph Manufacturing Company, 22 and 24 Church street, New York.	Takes globe without chimney.
31	Sunlight-slip	1-inch flat wick	11.91	1.6	.1343	2 25	E. J. Rice	Plume & Atwood Manufacturing Company.	Takes No. 2 B Lip chimney.
32	Prize, B No. 2	1-inch flat wick	12.24	1.65	.1348	1 50	S. J. Hogg	Bristol Brass and Clock Company.	Takes No. 2 Sun chimney.
33	Opposition, No. 2	1-inch flat wick	12.1	1.7	.1405	1 50	do	Benedict and Burnham Manufacturing Company.	Do.
34	Star, No. 2	1-inch flat wick	12.23	1.76	.1439	1 50	do	Holmes, Booth & Hayden	Do.
35	Leader, No. 2	1½-inch flat wick	16	3	.1875	3 00	The manufacturer	Bridgeport Brass Company	Takes special flat square base.
36	Pinafore, B	1½-inch flat wick	20.57	2.8	.1361	2 15	do	Gleason Manufacturing Company.	Takes special flat oval base.
37	Leader, No. 3	2-inch flat wick	25.60	4.4	.1718		do	Bridgeport Brass Company	Takes special flat square base.
38	Challenge	¾-inch diameter argand	11.16	1.4	.1254	2 75	do	Plume & Atwood Manufacturing Company.	Takes argand No. 2.
39	Perfection student lamp, Army burner.	⅞-inch diameter argand	16.83	2	.1188		do	Manhattan Brass Company	Takes argand No. 1.
40	Cleveland	1-inch diameter argand, study lamp.	18.7	2.3	.1230	† 33 00	S. J. Hogg	Cleveland Manufacturing Company.	Do.
41	Kent	1-inch diameter argand	17.16	2.2	.1282	6 00	do		Takes argand.
42	Harvard	1-inch diameter argand	14.08	2	.1420	7 00	The manufacturer	Plume & Atwood Manufacturing Company.	Do.

43	Manhattan, new	1¼-inch diameter argand	21.73	2.75	.1265	.....	do	Manhattan Brass Company	
44	Manhattan, mammoth	1⅜-inch diameter argand	21.85	3.3	.1510	.....	do	do	
45	Imperial	1⅜-inch diameter argand	22.61	3.8	.1680	18 00	S. J. Hogg		Takes special improved argand.
46	Schneider	1⅜-inch diameter argand	26.73	4.3	.1609	‡36 00	The manufacturer		Do.
47	Manhattan, duplex	21-inch flat wicks study lamp	18	3	.1666	15 00	do	Manhattan Brass Company	Takes regular duplex chimney.
48	Hinks, duplex	21-inch flat wicks	21.23	2.9	.1366	36 00	do	Imported	Do.
49	Multum in uno	2 1-inch flat wicks, with extingnisher.	20.8	3.4	.1635	.....	do	Wright & Butler, Birmingham, England.	Do.
50	Oxford, dual	2 1⅛-inch flat wicks, one flame.	15.16	2.2	.1451	5 50	E. J. Ricc	Plume & Atwood Manufacturing Company.	Do.
51	Mitrailleuse	10-$\frac{3}{16}$-inch round wicks, center ratchet	19.91	2.75	.1381	10 00	S. J. Hogg	Imported	Chimney similar to the larger Mohring.
52	Mitrailleuse	12-$\frac{3}{16}$-inch round wicks, center ratchet.	20.8	3.1	.1490	12 00	S. J. Hogg	Imported	Chimney similar to the larger Mohring.
53	do	12-$\frac{3}{16}$-inch round wicks, side ratchet.	22	2.7	.1227	12 00	J. F. Donnell	do	Do.
54	do	16-$\frac{3}{13}$-inch round wicks, side ratchet.	32	4	.1250	.....	do	do	Do.
55	York Torch	No wick (atomizer)	49.5	10.2	.2060	48 00	S. E. May		For lighting up field works, camps, landings, &c.

Brass, complete.

† Without glass.

‡ Complete.

TABLE No. 2.—*Supplementary tests by Army Board on lamps*, 1883.

No.	Name.	Kind.	Candle-power.	Oil consumed.	Oil consumed per hour per candle power.	Remarks.
				Ounces.	*Ounces.*	
1	Army (Perfection Student)	$\frac{7}{8}$-inch argand	17.77	3.05	.1969	Tested as student lamp, with constant level.
2	Cleveland (study)	$\frac{7}{8}$-inch argand	18.85	2.15	.1140	Do.
3	Mitrailleuse	$10\frac{3}{16}$-inch wicks round center ratchet	20.62	2.06	.1260	Tested in common font, with B collar.
4	Do	$12\frac{3}{16}$-inch wicks round center ratchet	21.23	2.03	.1083	Tested as student lamp, with constant level.
5	Do	$12\frac{3}{16}$-inch wicks round side ratchet, with carriage stops	23.83	3.05	.1468	Do.

NOTE.—The above tests were made with oil of 50° gravity and about 145° *flash*, being that furnished by the Quartermaster's Department at Fort Hamilton, New York Harbor, between the dates of September 1 and November 20, 1883.

R. JONES,
Lieutenant-Colonel, Acting Inspector-General.
D. PERRY,
Major, Sixth Cavalry.
J. A. FESSENDEN,
Captain, Fifth Artillery.
S. A. DAY,
First Lieutenant, Fifth Artillery, U. S. A., Recorder.

DESCRIPTION OF BURNERS TESTED BY ARMY BOARD ON LAMPS, 1883.

No. 1.

THE "GOOD NIGHT."

This burner and lamp is somewhat in the form of a candlestick and candle. It takes a three-eighths inch flat wick.

The chimney-holder, or crown and cone, are united and slip over the tube. It takes a small round chimney of the common Sun pattern, special size, and is intended to take the place of a candle for ordinary domestic purposes, and is a very handy little lamp, giving more light than a candle at much less expense, and will burn all night with very small expenditure of oil.

Nos. 2, 5, and 15.

THE "EUREKA."

There were three sizes of this burner submitted, Nos. 0, 1 and 2; No. 0 taking half inch flat wick; No. 1 taking five-eighths inch flat wick, and No. 2 taking 1 inch flat wick.

No. 0 the flame is 1 inch above the collar of the font; No. 1, $1\frac{1}{8}$ inch, and No. 2, $1\frac{1}{4}$ inches above the collar. It has a safety tube through which the vapor generated in the font is led to the flame alongside of the wick.

The cone is hinged to the diaphragm, and the chimney held in place by four stanchions of perforated spring brass grasping it on the outside. They take the ordinary Sun chimney, or cylindrical base chimney corresponding in number to the respective sizes.

Nos. 3, 9, and 20.

THE SUN.

This burner is made in three sizes, Nos. 0, 1, and 2, for half, five-eighths and 1 inch flat wicks, and are perhaps the best known in the market, being made in great quantities for export as well as domestic purposes.

The distinctive feature of this burner is that the cone is permanently attached to the diaphragm or base by four stanchions, and is spread out so as to fill and sustain the chimney from the inside. The base, or outer edge, of the cone being slit so as to form a spring bearing on the inside of the chimney about an inch above its base.

Nos. 4, 8, and 19.

THE LINCOLN.

This burner differs but slightly from the Eureka. The cone slot through which the flame passes being somewhat more elliptical in form than that of the Eureka. The diaphragm is attached to the base by a

greater number of points than the Eureka, but practically it is the same burner. It takes the Sun chimney corresponding in size to the number of the burner—0, 1, and 2.

Nos. 6, 16.

THE "SPRING HINGE."

This is made in two sizes, Nos. 1 and 2, and takes what are known as Nos. 1 and 2, or A and B lip chimneys. This burner has the chimney base and cone in one piece, and is hinged to the base above the diaphragm, through which the tube passes. It is also supplied with safety tube for escape of vapor.

The chimney is held in place by two points bent inward, over the lip on one side, and a spring piston opposite to these. Another spring secures the cone to the base opposite to the hinge.

These burners give a good, steady light, even when exposed to draughts, or puffs of air, probably due to the shielding of the tube beneath the diaphragm, as well as the small and numerous perforations in the diaphragm itself.

Nos. 7, 18.

THE STANDARD.

These are made in two sizes, Nos. 1 and 2; taking the corresponding Sun chimneys.

It differs but slightly from the Eureka burner already described made by the same firm. It, however, has no safety tube, and the stanchions are made of spring brass wire.

No. 10.

THE "SAFETY."

This burner requires no chimney, and as submitted was attached to a "packed" hand lamp.

Though, perhaps, useful in certain situations, is hardly adapted to burning kerosene oil with economy.

No. 11.

"CLEVELAND SAFETY."

This is a burner and lamp combined, and being inseparable.

The distinctive feature of which consists of a well and reservoir for the oil, the wick dipping into the former and the oil escaping from the reservoir, when in an upright position only.

This lamp is especially adapted for burning light volatile oils, and gives a good light.

No. 12.

SILBER LIGHT.

This burner is made upon the principle of supplying hot air to the flame by means of a jacket or shield surrounding the tube and conveying the heat downward, and through which the air passes upward, the shield being heated by near contact with the flame.

This requires no chimney, but like all of its kind tested by the Board is found to be somewhat wasteful in its consumption of oil, when compared with the amount of light produced.

One feature of the construction of this burner is a device for spreading the flame and exposing additional surface to the action of the heated air.

The burner is adapted for any lamp or font with common **B** ($1\frac{1}{4}$ inch) collar.

No. 13.

THE ALADDIN OR "LOCOMOTIVE HAND-LAMP."

This burner requires no chimney and resembles somewhat the preceding (Silber-light) in construction and principle, the differences being that the shield or heating jacket in this case is made of two pieces, a top and bottom, riveted together; the top being of brass and the lower of perforated tin.

It has also side openings in the cone, through which the flame passes when exposed to a downward or side draft, instead of being extinguished, and which, with other features, makes it a very fair burner for special purposes when used on a small hand-lamp or stand.

It is principally used in inspecting machinery where an ordinary lamp with chimney could not be handled.

No. 14.

THE LEADER.

This is a flat wick burner made in three sizes; the slip pattern being in two parts.

The base, circular, through and to which the wick tube is attached, while the slip or top is rectangular and uses a special chimney very much flattened.

No. 1 uses a 1-inch flat wick; No. 2 uses a $1\frac{1}{2}$ inch flat wick; and No. 3, or Mammoth, a 2-inch wick.

They are used for all purposes, either as hand, stand, pendant or bracket lamps, and a very good form is one with a barrel font, mounted upon a base with rod somewhat in the manner of a study lamp.

No. 17.

THE PARLOR, NO. 2.

This is a plain burner for a B ($1\frac{1}{4}$ inch) collar and B Sun chimney, which is held in place by four cut spring brass stanchions. The cone is hinged to the diaphragm, which in turn is riveted to the base. It takes a 1-inch flat wick, and for ordinary purposes is a good and effective burner.

No. 18.

THE EXCELSIOR, NO. 2.

This burner has a movable cone, the vest being solid, and is intended for use with an illuminator instead of chimney; the base of the illuminator being the same as a No. 2 or B lip chimney, and either can be used.

It takes a 1-inch flat wick and gives a good light.

No. 22.

THE PERFECTION, NO. 2.

This burner is of the standard pattern, having a hinged cone, a "safety tube," and four cut brass spring stanchions for holding the chimney in place, it taking a No. 2 Sun chimney.

No. 32.

THE PRIZE.

No. 33.

THE OPPOSITION.

No. 34.

THE STAR.

These are practically the same, taking the same wick and chimney, and giving about the same light for an equal quantity of oil, and differing only in a few details of construction.

These are all good economical burners, as will be seen by reference to the table, and are sold in great numbers at a very moderate price.

No. 23.

THE HITCHCOCK.

This burner is of the ordinary type, 1 inch flat wick, with cone over the tube and slot through which the air passes with the flame, and by which means the oxygen is supplied feeding the combustion.

The blast or excess of air in this case, however, is supplied by me-

chanical means, a fan being run by the unwinding of a coil-spring placed in the base, or stand. This, of course, like a clock, requires to be wound up periodically, and will run from 12 to 14 hours.

The flame is entirely exposed, and is more like a good quality of gas than any other submitted to the Board. It may be shaded or inclosed in a globe, if desired. The objections to this lamp are: First. The original cost consequent upon the necessity for the machinery, and its liability to get out of order when carelessly handled or trimmed. It gives a strong, steady light, and is economical in the consumption of oil, as will be seen by reference to the table.

Nos. 24 and 25.

THE UNIQUE.

This burner is made for different thicknesses of flat wicks, adapting it for use either with heavy or light oils.

No. 1, being intended for ordinary light oils, has a common wick 1 inch wide; in No. 2 the wick is of the same width but double thickness, the difference in the candle power and consumption of oil being very slight. This burner differs from all others on the same general plan in having a movable wick tube—that is, one capable of being depressed or drawn down beneath the diaphragm for the purpose of lighting and extinguishing without moving the chimney or globe, and is very convenient on that account. The tube is returned to and held in place by means of a coiled brass-wire spring.

This burner takes the No. 2 or B lip chimney and is very convenient for use with the illuminator, having the same lip, and in all pendant fixtures.

No. 26.

THE SUN-HINGE.

This burner has the cone and chimney seat, or base, combined, and is hinged to the base and diaphragm and base, and much resembles the spring hinge already described. It takes the lip chimney corresponding in size.

No. 27.

THE PINAFORE A and B.

These are made in different sizes, and, like the Leader, require special chimneys.

They are made upon the same principle as the Leaders, differing only in minor particulars. They give a good light and are economical in the consumption of oil.

No. 28.

THE DRUMMOND.

This burner takes a 1-inch flat wick and special chimney with round base held in place by catch and spring. It has a double diaphragm,

the lower one being flat and the upper decidedly convex, surrounding the tube and coming well up into the cone. The cone is sprung into and kept in place between catches.

The base screws into a common B collar, or can be fastened to the cap of a font by a partial turn or lantern catch.

It has a feeder wick, and the specimens furnished were specially adapted for use in a street lantern or post light.

They give good results and are excellent burners, especially suited for use out of doors.

No. 29.

THE HOLLINGS (NEW).

This burner resembles the Sun-hinge in many respects, differing principally in having a wick made up of three thicknesses of material folded.

No. 30.

THE M'LEWEE.

This lamp is patterned after and resembles in every respect the Hitchcock mechanical blast, except that the fan works are omitted from the base. It requires no chimney, but instead is substituted a globe of glass which answers every purpose of protecting the flame and supplying the draft. It has the 1-inch flat wick, gives a good light, and is economical in the consumption of oil.

No. 31.

THE SUNLIGHT-SLIP.

This burner takes the 1-inch flat wick and B or No. 2 lip chimney. It resembles the Sun-hinge, but the chimney base and cone slip over the tube and diaphragm, which are fastened together, the tube supporting the diaphragm.

No. 38.

THE CHALLENGE—ARGAND.

This was the smallest argand burner tested by the Board. It has a diameter of three-fourths of an inch and uses a flat wick in circle with double ratchet bearings. It takes the smallest or No. 2 argand chimney, and like all of its kind is economical in the consumption of oil when properly trimmed, but the difficulty of turning up all sides of the wick evenly, when not woven in cylinder, renders them generally undesirable.

No. 39.

THE PERFECTION—STUDENT LAMP.

This is the burner now largely in use in the Army for lighting barracks, &c. It is a seven-eighths-inch diameter argand of the well-known

student or constant-level type. It has good candle power and is economical in the consumption of oil, as will be seen by reference to the table.

No. 40.

THE CLEVELAND STUDY LAMP.

This is the well-known constant-level argand burner of 1 inch diameter cylindrical wick. It gives a strong, steady light, and is economical in the consumption of oil.

Excellent forms of this lamp were submitted, such as pendent, bracket, hand, and table lamps, some features of which have been embodied in the recommendations of the Board for the fixtures to be used in the Army.

No. 41.

THE KENT (ARGAND.)

This burner takes a 3-inch flat wick, as argand. It has a double ratchet, geared together, and operated by one thumb-piece. The inner tube takes its air through a side opening above the base, making a perforated wall surrounding the ratchets and tube. The inner tube contains a star-shaped lining at its top, extending about five-eighths of an inch down, intended for the purpose of steadying, dividing, and heating the inside draft to the flame. This burner takes a No. 1 argand or student lamp chimney, and gives a good light, and is economical in the consumption of oil, but, like all others having a divided or flat wick, is apt to turn up unevenly, and is difficult to wick or keep in order.

No. 42.

THE HARVARD.

This burner takes a 3-inch flat wick, like the Kent, in a 1-inch round tube, and is an argand. It has an inner tube which gets its air through a side opening above the base and inside of a perforated wall or shield surrounding the ratchets and wick-tubes. It has a cone surrounding the tube and a diaphragm, which is attached to the latter. The inner tube contains a cup at its bottom, which, being lifted out by means of a wire handle extending to the top of the tube, affords a ready means of cleaning it out.

This is a heavy burner of good power, but, on account of the mass of metal surrounding the wick, the flame is apt to increase after warming up, and requires careful attention when first lighted.

No. 43.

THE MANHATTAN (NEW).

This is a burner somewhat resembling the German student argand. It has a cylindrical wick $1\frac{1}{4}$ inches in diameter, which is raised and low-

ered in the usual way by revolving the wick-holder around an inner tube, the stud on the wick-holder working in a screw corrugation in the outer tube. The wick-sheath is perforated by a series of three circles of small holes to admit the oil to the wick, besides having a longitudinal slot through which the stud passes to the screw corrugation, the wick-holder being revolved by turning the wick-sheath. The sheath is attached at its top to an outer covering or cone, the outer wick-tube with corrugation screw coming up between the cone and wick-sheath nearly to the top. The cone descending to the level of the base is spread out horizontally, forming a diaphragm having three concentric rows of holes increasing in size toward the periphery. The outer circle of these holes serves as the gear in which a pinion works, and by which motion is communicated to the cone and wick-sheath by means of a key, and which serves to raise and lower the wick regulating the flame. The inner tube (to which oil is not admitted) is secured at the bottom, and the outer tube to both the bottom and sides near the top of a well $3\frac{1}{2}$ inches deep and $1\frac{3}{4}$ inches in diameter. This well has two perforations in its bottom to admit oil to the wick, and an air-hole near the top outside, and is attached to the base, which in turn screws into a metal cylindrical font 4 inches deep and $3\frac{3}{4}$ inches in diameter, intended for use in a vase or other receptacle.

The inner wick-tube holds a small button or spreader for the flame, which can be taken out when desired.

The chimney-holder is attached to a perforated cap which covers the revolving diaphragm, and on which a globe seat rests. The burner takes a large chimney of the student-lamp pattern and gives a strong, steady light of good quality, but in its present form was found unsuited for burning the heavy oil with which the tests were made, failing to empty the font before becoming extinguished.

No. 44.

MANHATTAN MAMMOTH.

This is in all essentials a large student lamp. It has a wick $1\frac{3}{8}$ inches in diameter, and the flame is regulated by revolving the cone and wick-sheath. The wick-holder stud running in a screw corrugation in the outer tube. It is attached permanently to a constant level font, which is intended to either set on a table or may be hung on the wall as a bracket. The font has a spring safety automatic closer. It takes a large student-lamp chimney and has a button flame-spreader permanently attached to the inner wick-tube.

No. 45.

THE IMPERIAL OR KASMOS VULKAN.

This burner takes a 4-inch flat wick in cylinder as an argand, the diameter being $1\frac{3}{8}$ inches. The inner wick-tube has a lining extending

about half way from the top to the bottom, concentric with which is a small tube for holding the button or flame-spreader.

The inner and outer wick-tubes are joined around a side opening, making a closed casing for the wick, which unites to complete the circle after passing this opening.

The cone, chimney-seat, and shield are all united and screw into the outer tube above the key, which, by double gearing, raises and lowers the wick regulating the flame.

The most distinctive feature of this burner is the chimney. This has a base, contraction, and shaft of the usual student-lamp form, except that starting just above the contraction the shaft is blown out into the form of a globe. The button, supported on a spindle passing through the contraction in the chimney, spreads the flame in the globe and produces a very intense and effective light. The burner is used in an ordinary font, but requires a collar two inches in diameter.

No. 46.

THE SCHNEIDER.

This burner resembles the Imperial (last described) in all essential particulars. It is mounted as a student-lamp or constant-level font, and the wick, being cylindrical, is raised and lowered by revolving the tube, as in all lamps of this class.

The outer casing of the font has a ledge or false bottom through which the nozzle of the feeder passes, closed, but on being turned around is opened and secured in place; a reverse motion necessarily closes the feeder before it can be taken out. It takes the chimney and gives nearly the same light as the Imperial, last described.

No. 47.

THE MANHATTAN DUPLEX.

This is a plain double or "duplex" burner, having two 1-inch flat wicks in tubes one-half inch apart. Each wick has a ratchet. The air passes in through the shield or surrounding case above the base and upward through a perforated diaphragm to all sides of the two wicks alike.

The cone has two openings corresponding to the wicks, between which is a line of depression. The chimney is held in place by a crown attached to the base of the cone, which fits over the top of the shield, a corrugation in the one and slot in the other establishing the correct lateral adjustment of the parts. Beneath the base a third wick is doubled through a staple and serves as a feeder to the movable wicks.

This burner takes the common duplex chimney, screws into a B ($1\frac{1}{4}$ inch) collar, and can be used on an ordinary font, and gives a good light.

No. 48.

HINKS DUPLEX.

This burner is like the last described, except that it has an extinguisher which, by movement of a lever, slides up the tubes and covers the exposed part of the wick at the top, and extinguishes the flames without turning down. It has no third wick or feeder, and as the length of the tubes is somewhat greater than in the Manhattan it is not well adapted for burning heavy oils, going out before emptying an ordinary font.

No. 49.

MULTUM IN UNO.

This burner differs from the Manhattan duplex, previously described, in being fitted with an extinguisher and the manner of attaching the feeder wick.

It also has an opening with cover, through the diaphragm and base, at the side of one of the tubes, through which the font can be filled. The wicks are wider, and it requires a larger collar in the font. It is used in a brass font with bottom rim fitting into a cup which screws on to an ordinary bracket or gas fixture. It has a globe mat surrounding the crown, and takes the common duplex chimney, giving a good light.

No. 50.

OXFORD DUAL.

This burner differs from the plain duplex in having but *one opening* through the *cone*, covering the tubes, by which means the flames from the two wicks are united above the cone. It takes the common duplex chimney, gives a good light, and can be used on an ordinary lamp or font having a **B**, or $1\frac{1}{4}$-inch collar.

No. 51.

THE MITRAILLEUSE.

This burner consists of ten brass tubes, three-sixteenths inch in diameter, and 3 inches long, arranged in a circle. They are secured in place at the bottom by passing through base plates, and at the top by a band one-half inch wide, and forming a plate even with their tops, and extending around the outer half of their circumferences. In the center of this circle of tubes is a single tube of the same size and length attached only at the bottom. Through this center tube runs a ratchet post, attached to a carriage beneath, by means of which the wicks contained in the outer tubes are raised and lowered.

Over the center tube another tube one-half inch longer telescopes

down to its attachment at the upper base plate. On the top surrounding this tube is a spreading disk or button, and another disk surrounds it one-half inch from the bottom.

The ratchet pinion is placed between the upper and lower base plates, which are seven-eighths inch apart, and the key passes through between two of the tubes, which are slightly separated at their base to admit of it, they all being about one-sixteenth of an inch apart at their tops. A second series of tubes attached to a disk at the bottom and free at their upper ends telescope upward into the first series. These carry the wicks, and the whole is raised and lowered with the ratchet post, which is attached to the center of the bottom plate.

The lower tubes from one-half inch above the plate are cut away on the outside exposing the wicks, leaving them in fact but half-tubes; the upper ends of these terminate in points, or beaks, which being turned inward when drawn down into the upper tubes with the wick are pressed into the same, by which means the wicks are raised and lowered inside of the stationary or upper tubes, and the flame is thus regulated. A perforated shield and chimney-crown, with a lining or cone also perforated, fit around the upper tubes to within one-eighth inch of their tops, the draft circulating freely both inside and outside of the circle of wick tubes above the base, while the vapor generated in the font finds vent through the center tube to the inside of the flame.

This burner goes into an ordinary B ($1\frac{1}{4}$ inch) collar and will draw heavy oil from an ordinary font. It takes a plain chimney, similar to the Mohring, which consists of two cylinders united by a cone without contraction, and gives a strong, steady light with small proportionate consumption of oil.

No. 52.

THE MITRAILLEUSE.

This is exactly like the preceding, except in size, having twelve wicks, and being larger requires a $1\frac{1}{2}$ inch collar to the font. It takes the same chimney and gives a proportionately greater amount of light.

No. 53.

THE MITRAILLEUSE.

This differs from the two preceding only in details of construction, and is the same size as No. 52. It has twelve tubes in the circle, and the center tube instead of being open is closed by the support holding the spreading button. The tubes at their top, instead of an outer band and half-plate through which they pass leaving their inner surfaces uncovered, as in the first described, abut beneath a full plate which extends downward both on the outside and inside, forming a band one-half inch wide on the outside and one-sixteenth inch inside.

It differs also in having the ratchet-post between two of the outer tubes, and consequently the pinion and key at one side. It has also a hinged stop at one side to prevent the carriage and inner or half-tubes with wicks being turned up so high as to expose the beaks to injury by the flame. This stop being turned outward permits the carriage to be run up to the full height when the wicks are first inserted into the tubes, or, when burnt down, a new length can be pulled up without breaking off the beaks, and which should be carefully guarded against.

No. 54.

THE MITRAILLEUSE.

This burner is like the last described in all essential particulars, with slightly different construction, but larger. It has sixteen wicks and requires a font with 1⅞-inch collar. It gives a very strong light; in fact, a more powerful light in proportion to the number of wicks than any other Mitrailleuse burner tested by the Board.

No. 55.

THE YORK TORCH.

This is a device for burning kerosene oil without wick or chimney, and is intended for use in exposed situations, such as field works, camps, landings, foundries, &c. It consists of a reservoir about 3 feet above the burner, to which the oil is fed by gravity through a tube, and is atomized by means of a small tubular jet in a heated retort. The vapor escapes through perforations, forming horizontal jets in a circle, which, being ignited, gives a strong light.

The pressure and supply of oil is regulated by two valves, and it is started by permitting a small quantity to overflow into a cup packed with asbestos beneath the retort, which, being lighted, heats the retort sufficiently to vaporize the already atomized oil admitted, which at once becomes ignited from the remnant of the oil burning in the cup beneath.

R. JONES,
Lieutenant-Colonel, Acting Inspector-General.
D. PERRY,
Major, Sixth Cavalry.
J. A. FESSENDEN,
Captain, Fifth Artillery.
S. A. DAY,
First Lieutenant, Fifth Artillery, U. S. A., Recorder.

WAR DEPARTMENT,
QUARTERMASTER-GENERAL'S OFFICE,
December 14, 1883.

GENERAL: I have the honor to submit herewith papers in report of Board on Lamps, convened by General Orders No. 127, Adjutant-General's Office, current series, with request that you will please favor this office with an expression of your opinion concerning the merits of the lamp recommended by the new Board, as compared with the Army lamp now in use.

Very respectfully, your obedient servant,

S. B. HOLABIRD,
Quartermaster-General, U. S. A.

Brig. Gen. M. C. MEIGS, U. S. A. (retired),
No. 1239 *Vermont Avenue N. W., Washington, D. C.*

WASHINGTON, D. C., *December* 15, 1883.

DEAR GENERAL: I have received the papers and report of a Board on Army Lamps.

I will prepare and send you some notes.

In the mean time, allow me to suggest that the photometric power of the lamp recommended by the Board be tested when the oil is nearly exhausted. Its value or candle light is not that determined when the bowl is full of oil, but varies, I judge, and its economy of oil will depend upon the mean candle-power.

I found, when I had to study this matter, that with the oil 2 inches below the top of wick-holder the light of the regulation Army lamp was 17.17 candles; when 4° below, only 8.92 candles.

In the new lamp I think that the oil, towards the end of the evening, will be 6 inches below the top of wick-tube, *i. e.*, below flame. This does not appear to have been considered by the Board.

M. C. MEIGS.

General HOLABIRD.

Mem.—The test measurement of light for the Board's lamp should be made by an expert. There is one with full photometric equipment at the office of the United States inspector of gas, in this city. He measures the value of the city gas every day. The measures should be taken with lamp full and one-half full and nearly empty, noting differences of level of oil and bottom of flame on each test. If you have two lamps please send me one to examine, or one after measurement made.

NOTES ON ARMY LAMPS.

To the subject of mineral oil lamps for use of the Army I gave long and careful attention and study.

The subject had been considered by a Board of Officers sitting at

Governor's Island, New York. They had recommended certain patterns of lamps. None of the lamps recommended by that Board, and none of those known to me as in common domestic use, appeared to fulfill all the conditions required for a lamp for use in barracks by soldiers.

I was therefore led to attempt to devise a form and construction which would meet the proper conditions as nearly as possible after this careful study. I think that when the danger caused by breaking or overturning is so great as in barracks, precaution against breakage and upsetting is of first importance. This led me to believe that the lamp adopted for general use should be one which should always, when lighted, be swung from the roof, or attached at a safe height to the wall of the room. Thus placed, only very uncommon carelessness, heedlessness, or malice would expose any of them to be broken or upset. The lamps adopted were, therefore, hung from the roof; and in order that they might be balanced and cast as little shadow as possible, two burners were arranged to be fed by each font or reservoir of oil in the suspended or pendent lamp. They are most useful for lighting up a long or large barrack room. For the use of small rooms, such as are occupied by non-commissioned officers a bracket-lamp was devised, one which could be safely and permanently attached to the wall, above the table on which the non-commissioned officer makes out his official reports and returns.

Long experience has convinced the civilized world that the most steady, agreeable, and, on the whole, best and cheapest light is obtained by use of the argand burner invented in 1782, by Argand, a Swiss chemist, residing in London. Its invention or rather its perfection was, it is said, the result of a happy accident. He had devised, thought and reasoned out the cylindric wick, supplied with air both on the exterior and interior, but it smoked, and the flame was lurid and dull. Disappointed and vexed, he sat in a brown study, when his servant or aid without any distinct purpose, placed over the flame a section of a glass tube. The flame sprang up into steady brilliancy, and the argand flame burner and chimney which have blessed many millions of houses for ninety-nine years, was complete. It is of universal use wherever economy of oil is not of greater importance than brilliancy of illumination.

The standard light now in all photometric establishments for the determination of the value of all methods of illumination, is a standard argand gas-burner, with a certain number of holes of fixed diameter, arranged in a hollow cylinder of fixed diameter, and with a glass chimney of fixed measured diameter and length.

If I do not greatly err, our Light-House Board and the light-house authorities in all civilized countries use argand burners in the sea-coast light-houses. For carrying about, for stables, ships, mines, and other places, lanterns whose portability is an object, and in the houses of the poor where economy in cost of the lamp and in use of oil are also essential, a great variety of lamps and lanterns have been devised, and the use of lamps is so large, and the capital devoted to their supply and

manufacture is so great, that ingenious inventors are constantly bringing out and endeavoring to introduce new forms of lamps and of burners. None have ever in public approval been able to displace the argand burner. It may be made large or small. The size of burner adopted for the Army lamp is believed to be well suited for the purpose. It gives, as appears from the report of this Board in the supplemental trials, the light of 16.83 to 17.77 candles. The standard gas argand burner is 16-candle power when used with 16-candle gas.

That this is a good standard, appears from the practice of the electric light companies who, while able to furnish a light of 1,000 to 100,000 candle power, all recommend for use in rooms of ordinary habitable size the 16-candle electric incandescent lamp. I did not ignore the ratchet method of raising and lowering the wick. I had such burners before me under trial. I preferred the more common arrangement of a wick raised by a screw, because I found common practice preferred it. I have been familiar with the ratchet in argand lamps, using whale oil, in my home when a boy, sixty years since. I think the screw better, but any of the common methods of adjusting the wick may be used in the Army lamp. If this supply is again advertised for contract, and another bids lower than the last contractor, he should be allowed to use any other argand burner than the one whose patent is owned by the company which happened when the Army was first supplied with mineral-oil lamps under my supervision as Quartermaster-General, to be the lowest bidders. An argand burner I think decidedly preferable to all others, and a $\frac{7}{8}$-inch burner the most suitable, but the details of construction of the tube and its elevating apparatus may vary, and are not prescribed. For the Mitrailleuse, it appears to be claimed by the report, that its capillarity is a special advantage. All wicks of the same quality and texture of cotton have the same capillarity; light oils rise higher than heavy ones. A difficulty with all oil lamps, is that the oil ascends by its capillarity and is liable to overflow the tube and, filling the drip-cup, finally overflow that also. This stops the supply of air through the interior tube, and causes the flame to close and smoke. The remedy is always to turn the wick well down into the wick-tube so that its edge may not remain above the top of the tube when the lamp is not lighted. Then, if the brass burner tube is kept clean and free from crusts or incrustations (which, themselves, being porous, have capillary attraction), will prevent this troublesome and dangerous overflow. The complexity of twelve or sixteen separate wicks in a lamp cannot fail to make it more liable to disarrangement and more troublesome to keep in order than the simple woven cylindric cotton wick so cheap and so lasting and in such universal use in student's lamps all over Europe and America. A wick in this lamp will last for many months. A great difference is made in the light power of the flame by the height of the wick and upper end of the burner tube above the level of the oil. I do not see this noticed by the Board. I had experiments

made on this subject when studying the question; they are of record and can be produced.* To avoid danger of overflow by tilting of the lamp, I desired to keep the burner as high as possible above the constant level of the oil; experiments were made in which they were tried at different heights, and the result was clearly to show that the nearer the oil rose to the level of the burner the higher was the flame without smoke and the greater the light produced. The result was a compromise and the difference of level was fixed as in the original specifications and drawings of the Army lamp at 2 inches ordinarily. I think $1\frac{1}{2}$ inches is used. I sacrificed some light to greater safety. I apprehend that if the Board had made photometric tests with the Mitrailleuse burner until the oil in the font, or reservoir, was *nearly exhausted*, they would have ascertained that the light produced, continually diminished until the oil was all consumed. The Army lamp, as made according to specifications and general orders, will burn for very many hours—sixteen hours—without any perceptible diminution of light. I have had them in constant use since the Army lamp was first made in my own library and study, reading, or drawing, or writing by them every night. I find that the best light is given by it when the flame burns clear and without smoke at an extreme height of $2\frac{3}{4}$ inches. Were the constant level of the oil much lower than now with reference to top of wick-tube, a constant flame of $1\frac{1}{2}$ inches in height would smoke and burn dim and red.

As light for working purposes, nothing better than that given by the Army lamp as now made is to be had. It is steadier and cheaper than gas-light. Electric light is not to be thought of in barracks, except in a city supplied with the powerful and costly apparatus necessary to produce it on a great scale. As regards heating the oil in the lamp, I think the ordinary student-lamp construction defective, yet I have never heard of an accident even in these. The oil in the burner tube gets heated, which prepares it for rapid distillation and conversion into illuminating gas in the upper end of the wick and is an advantage. The conducting power of the metal of which this tube is made conveys the heat down to some inches below the flame. Liquids conduct heat so slowly downwards that in a glass vessel a lump of ice a few inches below the surface of water contained therein, will remain unmelted, while a considerable quantity of ether or of light mineral oil is burned on the surface of the water. The conduction of heat to the store of oil contained in the font from the hot oil in the burner tube, is carried on by circulation alone. If the connecting tube is horizontal, or rises from the attachment to the burner tube towards the font, as in most student lamps, this circulation goes on and tends to heat, perhaps with light oils to a dangerous degree, the oil in the font. I therefore made this connecting tube longer than usual in student's and mineral-oil lamps, and formed it with a downward bend or inverted siphon. The oil heated and expanded in the burner tube cannot descend below or through the heav-

* Copy of reports herewith.

ier coal-oil in the lower part of this siphon, and thus the dangerous circulation and communication of heat thereby is absolutely prevented and the oil in the font is kept cool.

During some years' constant use I have never found the oil in the font heated much above the temperature of the air in the room where it is used.

Mitrailleuse.—I have never seen this lamp, but if I understand the description of its several sizes or varieties, all the metallic wick-tubes at some time, or whenever the lamp is full of oil, plunge into the oil itself.

This must be dangerous, for the metallic tubes will conduct heat downwards and aid to heat the oil in the bowl, which, in a warm climate or hot summer weather, must result in accidents. Moreover, it is stated in the description of the Mitrailleuse that the vapor collects in the glass font above the oil, which vapor, of course, increases in quantity as the surface of the oil descends, and the oil itself gets hotter and escapes through the central tube in the middle of the group of twelve wicks surrounding it. This is a positive source of inevitable damage and danger. The time will certainly come when this inflammable vapor will be mixed with air in explosive proportions, and the lamp must explode on being lighted, explosive mixtures of gases escaping in the midst of the flames of the surrounding wicks. In the constant level lamp this danger does not exist. The vacant portion of the font is removed to some distance from the flame, and is separated from it by a hydraulic trap or seal, so that there can be no communication of flame to the explosive mixture which is liable to form in every closed space above a liquid containing the very volatile materials which it is so difficult to separate entirely and absolutely from the oils distilled from petroleum. The filling cap and the burners of the Mitrailleuse are attached to a glass font at its top in two places. If this is done, as is usual, by plaster of Paris, then they will often, as I know by experience, get loose and come off. This is dangerous. If attached by the better method of the Manhattan Company's patent, of a coarse screw-thread molded on the glass neck and pressed or spun in the metal socket or cap, then they will not probably come off unless unscrewed, but they must, in order to be tight, be luted with some cement, or packed with leather, rubber, or other elastic collar, all of which are liable to become loose or leaky and dangerous. The form of lamp is objectionable. It tempts the soldier to set it on the table where it is liable to be upset or broken. If hung in a pendant or bracket it must cast a shadow below it. In the design accompanying the report of the Board a translucent glass shade is indicated. This or some reflector will be indispensable with this lamp. The parabolic or spherical, an adjustable reflector, nickel-plated, recommended for use with the regulation Army lamp, will give, over limited space at any point within 15 or 20 feet of the lamp, a light for reading or sewing equal to that of over 120 candles. It is not essential to lighting of bar-

racks, but it is useful, and would be found, I think, generally desirable in rooms of studious officers and of those who were disposed to cultivate literature.

The lamps under the contracts made under General Orders adopting them were furnished at very low prices. They have, I am advised, given great satisfaction to the soldiers. The reflectors cannot be used advantageously on a lamp whose body is so large as to obstruct the parallel beam of light. It will cast a shadow. The Army lamp, as I devised it, has a strong glass bottle for a font, so strong that I have never heard of one breaking. If broken, however, a common wine or beer bottle can be used in its place until the regular font can be obtained. It has no metallic parts attached to the glass by screws or cements or plaster to come off. It is closed tightly by a cork, and when taken off and filled, or while filling, it stands on a table or shelf on its flat end like any bottle, and can be closed by its cork so as to be handled as safely as a wine-bottle. The glass never corrodes or becomes leaky, as all metal fonts do in time, and is so strong that it is no more liable to break than a champagne bottle.

* * * * * * *

I think I have done a good thing for officers and soldiers, and I hope they will not be deprived of it. The only complaint that I have been able to hear of is the chimneys breaking. This happens with all bright and hot flames of lamps. Perhaps room for improvement may lie in the better annealing of the chimney and in some alterations of its form. Various forms are to be found in the market; almost any of them can be adapted to the present regulation Army lamp. I took, in the first place, the form in most common use. In my own library a chimney of the usual form, bought for a few cents at an Avenue store, sometimes lasts for months, and then, without apparent cause, breaks. Others break when first put to use.

If the edge of the metallic reflector is allowed to touch a hot chimney it is very apt to crack and ultimately to break. There is room for study, therefore, in the annealing and in the form and dimensions of glass chimneys for this lamp, and, perhaps, for improvement in the reflectors by enlarging the chimney-hole, so that under no circumstances shall the reflector and the hot glass come in contact. But to the chimney years of study and thousands of dollars have been applied by manufacturers in the past ninety-nine years since the argand burner was invented.

The conclusions of the Board are not justified by the record of their experiments. They, in fact, as was to be expected, show the greater advantages of the argand burner. If a stronger light be needed it will be better to use a larger burner. They compare a $\frac{7}{8}$-inch argand flame with a Mitrailleuse flame of more than $1\frac{1}{4}$ inch in diameter. The 10-wick burner is stated at $1\frac{1}{4}$ inches, and the 12-wick recommended as be-

ing larger. The following extracts from the general table of experiments I understand to be the results of trials under *usual conditions :*

No.	Burner.	Diameter.	Light in standard candles.	Oil used per hour.	Oil per candle.
		Inches.		*Ounces.*	
43	Argand	$1\frac{1}{1}$	21.73	$2\frac{3}{4}$	0.1265
44	..do	$1\frac{3}{8}$	21.85	$3\frac{3}{10}$	0.1510
39	Regulation Army lamp	$\frac{7}{8}$	16.83	2	0.1188
53	*Mitrailleuse, more than	$1\frac{1}{4}$	22.00	$2\frac{7}{16}$	0.1227

* This burner, as oil is exhausted and its level reaches from 3 inches to 6 inches below the flame, must give a light continually decreasing, and, finally, not half that reported.

NOTE.—Nos. 43, 44, and 39 will give a perfectly uniform light for many hours, and till oil is exhausted.

It appears that the regulation Army lamp consumes little more than half as much oil as No. 53, the one recommended by the Board ; that it consumes rather less for each candle-light obtained ; its light is steady for hours, and it is safe. It was adopted as a 16-candle burner for reasons before stated. The Mitrailleuse on its capillary bowl has a reservoir always filled with volatile vapor, which, when the lamp is in use, is reported as escaping through a central tube.

The time must come when the half-filled lamp will contain, above the surface of oil, an explosive mixture of air and vapor, and then, on application of the match to light the lamp, an explosion is to be expected.

Under ordinary circumstances the use of the regulation lamp is the less expensive in consumption of oil for light given, and of oil per hour, in the ratio as 2 ounces is to $3\frac{1}{2}$, in fact; and when a body of troops spends a Northwestern prairie winter without barracks, and the United States rebuilds the burned buildings, no one will think the substitution of the Mitrailleuse for the regulation lamp a happy or economical experiment. The regulation lamp holds 32 ounces of oil, and actually consumes in practice rather less than 2 ounces per hour per burner, so that it will furnish a steady light of 17 to 18 candles for 16 hours without refilling. Experiments made in 1881, at my instance, while I was engaged in the study of this question, showed that the quantity of light was greatly influenced by the difference of level between flame and oil. At 2 inches difference of level between flame and oil the light given by the regulation lamp burner was 17.17 candles, at 3 inches 11.68 ditto, at 4 inches 8.92, *i. e.*, only half that given at 2 inches. In the Bowl lamp recommended by this Board the difference of level varies as consumption goes on from 3 inches to 6 inches below the flame, as shown by the scale of the drawing. This has apparently escaped the attention of the Board, who seem to have estimated the light with a full lamp and consumption. With oil at a changing, say average, level, the ratio of its consumption per candle light will therefore be probably different from that stated by the Board. Before adopting this lamp, should it seem in any other respects preferable, the light-giving power should be tested at short in-

tervals from a full to a nearly empty lamp; the average will give its effective light and use of oil per candle power.

Waste of oil is caused by siphonage. The great capillary action of the wick raises oil to its upper edge, and if this is above the top of the wick-tube, or even therewith, the oil overflows, keeping the outside of the lamp wet, fills the drip cup, and overflows upon the table or floor. With the argand burner, kept clean and free from incrustation, this can be entirely prevented, and both damage and danger avoided by turning the wick down to a sensible distance below the top of the tube when extinguishing it, and leaving it so. A wick thus treated will last for a year without changing, when used with oil of the purity required by the Quartermaster's Department in its specifications and contracts.

I have constantly used in my library and study, since they were first made, the regulation Army lamp, and my own experience agrees with that of the Army. They are satisfactory to those who use them and to those who buy the oil they consume.

The large size of the bowl lamp makes it unfit to use with the parabolic reflector, as it cuts off a great part of the light. This reflector, properly adjusted, will throw upon a book at a distance of 10 to 20 feet a light equal to the power of 150 candles. It is, therefore, very desirable for reading and writing. The light given out by the lamp is not increased in actual quantity by the use of a reflector; it is collected upon a comparatively small space, and less light goes to the walls and roof of the room. For general illumination of a room the reflectors should not be put upon the lamps—they are arranged to be removable.

In the first table of tests, No. 1, where the burners and lamps appear to have been observed under ordinary conditions of use—the Mitrailleuse, No. 53—12 wicks and side ratchet used 2.7 ounces oil per hour, giving light equal to 22 candles, and is reported to have used per candle light 0.1227 ounces oil. The Army lamp used 2 ounces of oil per hour, and gave 16.83 candle light, a consumption per candle of 0.1188 ounces per hour, which is less than that of the burner recommended.

In the second table in which experiments appear to have been instituted to compare the burners not under ordinary conditions, but with the argand lamp pressed beyond its regular work, it was forced to a consumption of $3\frac{1}{2}$ ounces per hour, giving under these conditions, 17.77 candle light, and using per candle 0.1969 ounces of oil.

The Mitrailleuse, used as a constant-level student lamp, gave, by this table, 23.83 candle light; used $3\frac{1}{2}$ ounces oil, and per candle 0.1469 ounces. It was burning at disadvantage for addition of 0.8 ounce of oil, increased light was 1.83 candles only The former is the fair comparison, the Army lamp then working at its usual and constant rate, which, in practice, is rather less than two ounces per hour, and the Mitrailleuse then being used in the capillary lamp recommended by the Board, in which I am persuaded that it will be found to give, as an average working light as the oil gets lower in the glass bowl, a good

deal less light than the Army lamp with $\frac{7}{8}$-inch argand wick which, moreover, gives a perfectly steady light for 16 hours continuously.

The Light-House Board uses an argand mineral-oil lamp with three concentric wicks, the outer one $2\frac{5}{8}$ inches in diameter. It consumes $15\frac{1}{2}$ ounces oil per hour; gives light equal to 163 candles, and uses per candle light per hour 0.0958 ounces mineral oil, Light-House standard. (See report and correspondence with the Manhattan Brass Company upon tests of lamps with oils at different levels, and the remarks of their experts upon capillary action of oils on wicks at different temperatures and effects on flame and light, which are herewith.)

M. C. MEIGS,
Late Quartermaster-General.

NEW YORK, *May* 21, 1881.

DEAR SIR: We inclose copy of photometric test made for us, which we respectfully submit for what it is worth.

Of course if left to us we should prefer to make in regular way, being all prepared to do it. Such being the case, we do not think we should give any other reason for our preference of less oil level than 4 inches.

Very respectfully, yours,

MANHATTAN BRASS COMPANY.
J. H. WHITE, *President.*

General M. C. MEIGS.

NEW YORK, *May* 23, 1881.

DEAR SIR: We omitted to say on sending the photometrical results, I fear, they were made with the wick of a uniform height of $\frac{3}{32}$ inches above the top of burner. This is the usual and proper height for our burners for oil levels of from $1\frac{1}{2}$ to 2 inches.

In making the burner for 3 or 4 inches level it would be necessary to raise the chimney to correspond to the increased height of wick. This, we think, would give somewhat better results.

Very respectfully, yours,

MANHATTAN BRASS COMPANY.
J. H. WHITE.

General M. C. MEIGS.

The following will show the photometrical results obtained with your argand burner, and as may be expected from any other, subject to the same trial with good oil and a soft well-made wick, best adapted for the purpose, which was found by actual experiment and usage.

The oil used in making this experiment was of an excellent quality, flash at 140° Fahr. Its capillary power very good. The latter is not requisite in the market; therefore the oil may stand all market requirements, such as color, specific gravity, flash, and fire tests, yet the capil-

lary power be defective, and the production of light in a lamp having its level of oil below the usual height would produce less light.

Oil level 4 inches equal to 8.92 candles.
Oil level 3½ inches equal to 10.87 candles.
Oil level 3 inches equal to 11.68 candles.
Oil level 2½ inches equal to 12.25 candles.
Oil level 2 inches equal to 17.17 candles.
Oil level 1½ inches equal to 18.87 candles.

[Indorsement by General Meigs.]

Conclusive: 4-inch oil level gives one-half light of 2 inches level. Strike out the specifications requiring 4 inches level.

M. C. MEIGS.

Q. M. G. O., *May* 23, 1881.

NEW YORK, *May* 26, 1881.

DEAR SIR: We have your favor of 24th, and shall take pleasure in obtaining such additional information as you request as soon as possible. The former tests were made, as we wrote you, with the wick at uniform height above the burner, but no memorandum was made of length of flame. We have ordered another test with such record as your letter would indicate as desirable, and will send you as soon as received.

Very respectfully, yours,

MANHATTAN BRASS COMPANY.
J. H. WHITE, *President.*

General M. C. MEIGS.

NEW YORK, *May* 30, 1881.

DEAR SIR: We sent copy of your request of the 24th instant to the gentleman who made photometric tests for us, with the request to make the answer as full and complete as possible.

We inclose herewith reply just received. If it does not satisfactorily answer all questions, please advise, and we will endeavor to obtain all you may desire.

Very respectfully, yours,

MANHATTAN BRASS COMPANY.
J. H. WHITE, *President.*

To give you a better idea of the different changes produced in the light in changing the level of oil in the burner, I would first state that the average production of light obtained in a lamp having its level of oil, say from 3 inches to 4 inches below the surface of burner, depends

altogether upon quality of oil used. A common oil of 100° flash test,* owing to the large amount of naphtha in it, would flame higher and brighter in a warm room, in connection with the gradual heating of the burner, than an oil of 140° flash test.

In a lamp placed in a cold room, say temperature from 50° to 60° Fahr., the oil level should not be less or below 1½ inches from the surface of burner. If the temperature of the room is above that, and with the additional heating of the lamp, 2 inches level would produce the same result in height of *flame and brilliancy.* The difference observed in the flames of various oil varies in height as well as in brilliancy. I will relate the manner in which I made the foregoing test, being so simple that without the photometrical apparatus it can be readily ascertained.

The temperature of the dark room was 53° Fahr.; the burner was adjusted to a student lamp, oil level at 2 inches; having burned for about one hour, the wick gradually turned up, to obtain the best possible light; the latter was fully three-sixteenths inch above the burner. When the first photometrical test was made, the flame above the wick was 1¼ inches in height, appeared to be white, but without brilliancy, as results have shown. To change gradually the different heights of the oil, stems of the different heights were made, having at the lower end attached a round piece of sheet tin, size of a quarter dollar, the latter to keep the font level at its bottom end; the stem was slid over the projecting wire, forming part of the valve which admits and shuts off the oil in the font. After each photometrical test, the font was removed and the oil was taken out and replaced after the stem was properly adjusted, to be certain of the oil level. In each case it was plainly visible without moving lamp or wick. The flame would raise in height and brilliancy; at the last test the flame was fully 4½ inches in height. To depend on a thick wick as a substitute to a high level, which is frequently done to assist the capillarity of the oil to supply the burning flame. This very often is believed, that the required difference in height is obtained because a high flame with a low level is produced; but this is a mistake. In all cases where a high flame is formed in that manner it will have a dim appearance, consuming a large amount of oil, of which a great portion is lost in an invisible but offensive smoke, and very defective in the illuminating power.

WAR DEPARTMENT,
QUARTERMASTER-GENERAL'S OFFICE,
Washington, D. C., January 7, 1884.

SIR: I have the honor to request that you will please cause careful photometric test to be made of accompanying mineral oil lamp, to which is fitted Mitrailleuse burner, and accompanying which is a can of mineral oil having a flash test of about 140° Fahr., and specific gravity of about 47° Baumé.

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* United States uses 135° flash.

It is desired that the photometric power of this burner be noted when the lamp is filled to the level of the bottom of the brass collar which is 3⅝ inches from bottom of the flame, and at each successive increase of 1 inch of the level of the oil until the lamp is nearly empty.

Two extra chimneys are furnished herewith for use in case of breakage.

Very respectfully, your obedient servant,

S. B. HOLABIRD,
Quartermaster-General, U. S. A.

S. CALVERT FORD, Esq.,
United States Inspector of Gas,
No. 403 Tenth Street Northwest,
Washington, D. C.

OFFICE OF THE
UNITED STATES INSPECTOR OF GAS AND METERS,
Washington, D. C., January 14, 1884.

SIR: Your communication with lamp and oil received. In reply I have the honor to inform you that I have made photometric determinations on the Bunsen photometer, with the mineral oil lamp, to which is fitted a Mitrailleuse burner; the power of the light furnished by lamp was compared with a standard sperm candle burning 120 grains per hour. The following results were obtained.

EXPERIMENT No. 1.—In this test the lamp was nearly filled with oil; the flame was uniformly high during the entire time required to make twenty observations, and the illuminating power was found to equal 20.36 standard candles; rate of oil consumed, 1,245 grains per hour.

EXPERIMENT No. 2.—In this test the oil in lamp was 1 inch lower than in Experiment No. 1; the flame was fair, but could not be maintained at the same height as in the former test; the illuminating power was found to equal 15.81 standard candles; rate of oil consumed, 963 grains per hour.

EXPERIMENT No. 3.—In this test the oil in lamp was 2 inches lower than in Experiment No. 1; the flame was not near so good as in Experiment No. 2; the illuminating power was found to equal 10.04 standard candles; rate of oil consumed, 843 grains per hour.

In Experiment No. 1, 61.14 grains of oil yielded a photogenic power equal to one sperm candle burning 120 grains per hour.

In Expeniment No. 2, 60.90 grains of oil yielded a photogenic power equal to one sperm candle burning 120 grains per hour.

In Experiment No. 3, 83.96 grains of oil yielded a photogenic power equal to one sperm candle burning 120 grains per hour. In the first and second experiment, the photogenic power obtained was about the

same for an equal consumption of oil; but in the third experiment the photogenic power was not near so good.

Very respectfully,

S. CALVERT FORD,
Inspector of Gas and Meters.

General S. B. HOLABIRD,
Quartermaster-General, U. S. A.

WAR DEPARTMENT,
QUARTERMASTER-GENERAL'S OFFICE,
Washington, D. C., January 16, 1884.

MY DEAR GENERAL: In accordance with your request of the 15th ultimo, herewith is furnished for your inspection mineral oil lamp, to which is attached a Mitrailleuse burner, recommended by new Board on Lamps for adoption in the Army; and your attention is invited to accompanying report, made upon your suggestion, by the United States inspector of gas and meters in this city, as to photometric power of the burner in question.

The report of the Board is returned herewith for such additional notes thereon as you may desire to make.

Very respectfully, your obedient servant,

S. B. HOLABIRD,
Quartermaster-General, U. S. A.

Brig. Gen. M. C. MEIGS, U. S. A. (retired),
No. 1239 *Vermont Avenue, Washington, D. C.*

WASHINGTON, D. C., *January* 21, 1884.

GENERAL: I return the Mitrailleuse 12-wick lamp, which I have examined and tried; also the report of the Board of Officers recommending its adoption for Army use, and the report of tests of its consumption of oil and its illuminating power at the United States laboratory by the Government gas inspector for the District, Mr. Ford.

This report confirms my opinion that, as the level of oil falls in this lamp, which is not a constant-level lamp, the illuminating power and the consumption of oil will decrease.

He finds with a full lamp a light of 20.36 candles, with oil consumption of 2.84 ounces per hour. When oil surface is one inch lower, light 15.81 candles, consumption per hour 2.20 ounces. This is the mean height, and, therefore, probably mean average light and consumption of oil. When oil surface is two inches lower than when full, light is 10.4, consumption of oil is 1.92 ounces per hour.

The United States Army regulation constant-level lamp, with seven-eighths inch argand burner, gives, as per report of Board, when not

pressed beyond its proper rate of burning, experiment No. 39 of their tabular statement, 16.83 candle light, with consumption of 2 ounces oil per hour—less oil and more light than the average of Mitrailleuse. If a stronger light is needed for any special situation or work, an argand burner of 1 inch or of 1½ inches in diameter can be used, which will give a much stronger light. These experiments show that the universally preferred argand or student-lamp burner is as economical as the Mitrailleuse, while it is of much less complicated construction, and on a great scale will probably be less costly both in construction and in consumption of oil.

I find on examination of this burner that the open central tube through which the vapor escapes from the space above the oil in body of the lamp is practically, in use, intended to be closed, though not quite air-tight, by the inserted metallic stem of the brass deflecting button in the middle of the flame. This stopper prevents explosion while in place, but as it is liable to be displaced by accident, by carelessness, or ignorance of its importance, it must be a source of danger. It would be improved if a loose-fitting screw-thread were cut in stem and in pipe. This lamp is liable to be filled with an explosive mixture of air and vapor, and to be lighted without this loose stopper being in place.

If this happens an explosion must follow. Were it not for this danger I should consider the burner a good one for a portable lamp. There are situations in which such a lamp, which can be carried about and set upon a table or mantel shelf, is useful. But for lighting up the barrack rooms of troops safely is all important. The regulation lamp is safe and gives as cheap a light, and with same consumption of oil, one quite as brilliant. It cannot be detached from its support and set upon a table to be upset or broken. I understand that the *missile* most tempting to a drunken man is a lamp.

The Mitrailleuse casts a wide shadow, from which the regulation lamp is free. I find that standing on a table the Mitraillense shadow is 9¾ inches in diameter; raised 1 foot above the table it is 21½ inches wide; this makes a hood or reflecting shade necessary, which costs money and which absorbs a very large portion of the light produced by the flame.

The flame is 1½ inches in diameter, and at 2⅛ inches in height I find the consumption of oil to be in ordinary use 2½ ounces per hour, the temperature of the room being from 62½° to 67½°. Trying the regulation Army lamp with seven-eighths inches argand burner, flame 4 inches tall, I find consumption of oil to be 12 ounces in six hours, a perfectly regular rate of 2 ounces per hour, without any variation in height or brilliancy of the flame, and this continues without refilling the lamp for nineteen hours. Regulating the flame to be 2 inches tall, the flame continued brilliant and steady at that height during six hours, the duration of the experiment, and the actual consumption 8¾ ounces of oil, a rate of 1.441 ounces per hour. The double pendent regulation lamp will give, with a consumption of 4 ounces per hour, a light of 33⅓ candles, and can be

regulated to give any less light with correspondingly reduced expense of oil. The suspension frame for the Mitrailleuse lamp contains 5 feet of one-half inch gas-tube, against 2 feet of the same in the double pendent regulation lamp of 33⅓ candle power, and against 1 foot of the same in the regulation bracket lamp of 16.83 candle power. The spun and pierced metal bowl, glass font, burner, and other parts, cannot be much, if at all, less costly than those of the regulation lamp. The bracket recommended for the Mitrailleuse is evidently more expensive than the regulation bracket. Considering performance, economy of supply, and maintenance and safety, I see no sufficient reason to justify the recommendation of the Board to substitute the Mitrailleuse for the argand lamp, and it seems to me that it would be imprudent to allow the use in United States barracks of a lamp liable as the Mitrailleuse is to dangerous accident. The 12-wick Mitrailleuse burner is practically an argand burner composed of 12 parallel threads kept separate in order to allow the admission of air between the threads to the interior of the flame when the burner is used upon a bowl or vase and not upon a tube, stem, or branch. It has no advantages over the argand burner except its applicability to a lamp of the form reported on by the Board. The flame splits into 12 tails at the top. I find that the example before me will not bear without smoking a greater height of flame than about 2⅛ inches; its light when full of oil is 20⅓ candles, and consumption per hour 2.84 ounces of oil. The regulation Army constant level lamp with ⅞ inch wick gives 16⅞ candles, or rather less than 2 ounces oil. The Light-House Board has a lamp with wick 1⅜ inch diameter giving 54 candle light with 4⅓ ounces oil per hour; others of various sizes and various consumption of oil. Greater light can be had for the regulation Army lamp by diminishing the height of wick tube above oil level, but this will be attended with greater risk of overflow and spilling of oil. I conclude that when a vase and portable lamp is needed the Mitrailleuse is an ingenious and effective burner, but complicated and somewhat dangerous in itself, and subject to all the objections for barrack rooms which attend table and portable mineral oil lamps. Its safety would be increased by fitting the stem of the deflecting button into the pipe in the center of the burner by a well cut but loose screw, one which would prevent the stopper from being lifted out without unscrewing it, and yet be loose enough to allow the entrance of a thread of air along the circuitous passage of the threads of the screw.

I return all papers herein.

I remain, very respectfully, your obedient servant,

M. C. MEIGS,

Bvt. Maj. Gen., U. S. A., Brig. Gen. (retired).

General S. B. HOLABIRD,

Quartermaster-General, U. S. A.

WASHINGTON, D. C., *January* 24, 1884.

DEAR SIR: I wish to add to my note of January 21, in reference to the Army lamp, that after it was closed I compared with a rude photometric apparatus the light of a Mitrailleuse when nearly empty, the oil level being then 0.84 inches lower than in Mr. Ford's experiment No. 3, and found the light of the Mitrailleuse lamp to be 6.2 candles only.

I estimate the oil levels in these tests to have been below top of burner—

No. 1.—3.94 inches; light, 20.36 candles.
No. 2.—4.94 inches; light, 15.81 candles.
No. 3.—5.94 inches; light, 10.04 candles.
No. 4.—6.78 inches; light, 6.20 candles.

which is a loss of nearly 5 candle-light for each inch depression below No. 1. The average light during the life of a charge of oil is thus about 13.1 candles against a steady light of 16.82 candles.

The consumption of oil through the whole life of one charge of oil, "17½ hours," was 2½ ounces per hour. Average light, 13.1 candles. The Army lamp consumed 2 ounces per hour, with a regular and constant light of 16.82 candles.

The report of the Quartermaster-General for 1882, page 11, shows there are in use—

	Burners.
5,156 bracket lamps	5,156
1,782 pendent double lamps	3,564
Total in Army	8,720

which used 216,414½ gallons of oil.

If the Mitrailleuse be substitued, its consumption being 2½ ounces instead of 2 ounces per hour, or 25 per cent. greater, the consumption of oil would be 25 per cent. greater, or 270,518.1 gallons, an increase of 54,103.6 gallons, costing, at present contract rates, 19 cents per gallon, $10,279.68, which does not promise any great economy for the substitution of the Mitrailleuse for the argand burner lamp. But the greatest objection is the danger of using in barracks a portable table lamp.

I am, very respectfully, your obedient servant,

M. C. MEIGS,
Bvt. Maj. Gen., U. S. A., Brig. Gen. (retired).

General S. B. HOLABIRD,
Quartermaster-General, U. S. A.

[Manhattan Brass Company, First Avenue, Twenty-seventh to Twenty-eighth streets.]

NEW YORK, *January* 25, 1884.

DEAR SIR: Yours at hand. There are practically grave objections to the 12-wick burner. In the first place, it is very difficult to wick

the burner, taking about half an hour. Then it will not, unless very carefully trimmed and handled with great care, burn at all evenly; then some of the wick naturally chars and the burner throws off smoke instead of clear light. This is very objectionable in the Army, where everything needing careful treatment, with the naturally rough usage, will make them soon useless.

It also burns with such great heat that only a metal lamp will stand it, and altogether is for such use impracticable.

* * * * * * *

Yours,

J. H. CRANE, Tr.

General M. C. Meigs,
Washington, D. C.

[Extract from a letter from the Manhattan Brass Company, makers of the regulation lamp.]

I had no occasion to put a wick in, and during my short trials the burner behaved well, though its light continually and regularly decreased from hour to hour.

M. C. MEIGS,
Bvt. Maj. Gen. U. S. A., Brig. Gen. (retired).

The Quartermaster-General, U. S. Army,
Washington, D. C.

War Department,
Quartermaster-General's Office,
Washington, D. C., February 19, 1884.

General: The Equipment Board in this office having, pursuant to your instructions, maturely considered the question of any change in the mode of lighting Army barracks, has the honor to submit the following report:

The following papers relating to the subject which were referred to the Board have been carefully considered by it, viz:

First. The report of Board on Lamps, convened in New York City by Special Order No. 127, Adjutant-General's Office, June 4, 1883, which recommends the substitution of the Mitrailleuse burner with glass bowl for that now in use known as the "Army lamp."

Second. "Notes on the Army lamp," by Bvt. Maj. Gen. M. C. Meigs, late Quartermaster-General, United States Army.

Third. Report of a photometric test of the Mitrailleuse burner, made by the United States inspector of gas and meters in this city.

The opinion of the New York Board as to the merits of the Mitrailleuse burner may be summed up as follows:

1. Its high candle power.

2. Its economy in consumption of oil.

3. Its adaptability for burning in an ordinary font the heavy grade of oil furnished to the Army, thus dispensing with constant level lamps, of which the present Army lamp is a type—the great capillarity of the wicks being sufficiently strong to draw the heavy oil high enough above its natural level to empty an ordinary lamp font.

In the opinion of the Equipment Board the objections to the Mitrailleuse burner with glass font, recommended by the New York Board, as compared with the Army lamp, may be summarized as follows:

The wicks are raised and lowered with a ratchet, an objectionable feature as compared with the mode of raising the wick which obtains in the Army lamp on account of liability of ratchet to get out of order.

The Mitrailleuse burner is recommended by the New York Board to be used with the common capillary or well lamp bowl; and that Board refers to its great capillarity as a commendable feature compared with the constant-level principle; assuming it to be preferable to draw the oil by capillary attraction from 4 to 6 inches or more, as the case may be, than from 2 inches as in the Army lamp.

In the latter the oil is prevented from becoming hot, and thereby liable to flash or take fire, by a constant influx of cold air through opening in drip-cup, and through the tube around which the oil is conducted from the font to the point of combustion.

In the Mitrailleuse burner the large number of wicks, the trouble in wicking the tubes, the difficulty in maintaining a steady flame, the liability of the ratchet to get out of order, the danger of explosion by reason of deflecting button in gas or vapor tube becoming displaced, or by conduction of heat downward by the brass tubes holding the wicks, and the danger to be experienced by having the lamp portable, are, in the judgment of the Equipment Board, objections so grave as to forbid the recommendation for its adoption for Army use.

It is exceedingly difficult to maintain a steady light with the Mitrailleuse burner for any great length of time—slight incrustations likely to form upon any one of the many wicks cause the wicks to burn unevenly, the flame to dart up the chimney, and the lamp to smoke and emit an unpleasant odor; to remedy which, either the chimney must be removed (a disagreeable operation on account of the *intense* heat thereof and of the surrounding brass-work), or the light must be turned down to accommodate the smoking wick, thereby greatly reducing the power of the light.

Another great objection is the mode of attaching the burner to the glass font by plaster of Paris, which, after becoming saturated with the oil, is liable to granulate and cause the collar to work loose.

On account of the construction of the Mitrailleuse lamp as recommended by the New York Board, a shadow is necessarily cast over a considerable area beneath, whereas but little perceptible shadow is thrown by the Army lamp.

The photogenic power of the Mitrailleuse burner, as stated by the New York Board (see table herewith), was not confirmed by test made of that burner by the United States inspector of gas and meters in this city, Mr. S. Calvert Ford, an expert, with full photometric equipment, Bunsen's photometer being used.

The New York Board gave the power of the Mitrailleuse burner as follows: Candle power, 22; oil consumed per hour, 2.7 ounces; oil consumed per hour per candle power, .1227 ounce, when tested with bowl lamp.

Mr. Ford determined the power of the Mitrailleuse burner to be as follows:

With full lamp, oil $3\frac{5}{8}$ inches from bottom of flame, candle power, 20.36; consumption of oil, 2.84 ounces per hour; oil consumed per hour per candle power, .1394 ounce. With oil $4\frac{5}{8}$ inches from bottom of flame, candle power, 15.81; consumption of oil, 2.20 ounces per hour; oil consumed per hour per candle power, .1391 ounce. With oil $5\frac{5}{8}$ inches from bottom of flame, candle power, 10.04; consumption of oil, 1.92 ounces per hour; oil consumed per hour per candle power, .1912 ounce.

The Army lamp with wick seven-eighths of an inch in diameter, against that of the Mitrailleuse burner of $1\frac{1}{2}$ inches in diameter, consumes less than 2 ounces of oil per hour, and emits a steady, brilliant light of 17 to 18 candles for more than sixteen hours without refilling, and without danger from explosion.

The power of the Army lamp can be greatly increased by increasing the size of the wick.

Constant level lamps with argand burners, such as the Army lamp, have stood the test of public trial and given satisfaction, and are fast superseding lamps used with ordinary bowl font, on account of safety, ease of operation, and increased light.

The Mitrailleuse burner and modifications thereof have, it is learned, been tested by dealers, and generally discarded on account of danger likely to result from the lamp becoming heated and the other objections herein stated.

We read daily of explosions of lamps constructed on the old bowl plan, such as that recommended by the New York Board; but rarely does an accident occur with student lamps or constant level lamps, for the reason that the gas, as soon as generated in the spiral tube, becomes ignited, and instead of exploding aids the lamps in emitting a steady and brilliant light; whereas in the bowl lamp, of which the Mitrailleuse is a sample, volatile gas must of necessity accumulate in the bowl, and in case of displacement of deflecting button, might, it is believed, frequently cause explosions.

The Army lamp has proved to be a success. Complaint has, however, been made because of frequent breakage of chimneys, but since a better class of chimney has been provided, less complaints have been received and requisitions therefor have been *materially* reduced.

Inasmuch as the Army lamp, the result of much careful thought and study, appears to be giving general satisfaction, no sufficient reason is, in the opinion of the Equipment Board, shown for displacing the same by a lamp having so many objections and so few merits as the Mitrailleuse.

The New York Board says that great improvements have been made during the last few years in devices for burning kerosene oil.

The Army lamp was adopted for use in the Army about two and one-half years ago, and upwards of 8,000 thereof have been purchased therefor at a cost, including fixtures, in round numbers of $40,000.

The Army appears to be satisfied therewith. It is fair to presume that improvements may be made in the Army lamp as in all other inventions and projects. Recognizing this fact, the Equipment Board is of opinion that it would hardly be wise to discard a lamp which gives great satisfaction, and to supply the Army with which has cost many thousands of dollars, for another lamp which in turn would be likely to be superseded by still another modification.

In view of all the facts presented, the Equipment Board recommends that no present change be made in the mode adopted for lighting company barracks.

J. G. CHANDLER,
Deputy Quartermaster-General.
O. G. SAWTELLE,
Deputy Quartermaster-General, U. S. A.
R. N. BATCHELDER,
Deputy Quartermaster-General, U. S. A.
JOHN F. RODGERS,
Captain and Military Storekeeper, Recorder.

The QUARTERMASTER-GENERAL,
United States Army.

These proceedings are approved.

S. B. HOLABIRD,
Quartermaster-General, U. S. A.

WAR DEPARTMENT,
QUARTERMASTER-GENERAL'S OFFICE,
Washington, March 7, 1884.

Respectfully returned to the Adjutant-General of the Army, inviting attention to accompanying report of the Equipment Board of this office, in whose opinion, which coincides with that of the first Board on Lamps (copy herewith), as to the superiority of the constant level principle in lamps which is embodied in the present Army lamp, the Quartermaster-General fully concurs.

In view of the importance to the Army of the question of lighting barracks, the Quartermaster-General suggests and recommends that a

statement showing action had in this matter since the project of using mineral oil in place of candles was first considered by the War Department be published for information of the Army; and with a view to this end, a brief sketch of the action had in the case prior to adoption of present Army lamp, including report of Governor's Island Board and a fair copy of report of New York Board, with notes thereon, and of report of the Equipment Board in this office, prepared for the printer, are herewith.

S. B. HOLABIRD,
Quartermaster-General U. S. A.

HEADQUARTERS OF THE ARMY,
Washington, D. C., March 15, 1884.

Respectfully submitted to the honorable Secretary of War, concurring in the indorsement of the Quartermaster-General.

P. H. SHERIDAN,
Lieutenant-General.

Respectfully returned to the Quartermaster-General, approving his recommendation.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

WAR DEPARTMENT, *March* 17, 1884.

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SPECIFICATIONS

FOR

LAMPS FOR MILITARY POSTS.

The lamps shall be of two patterns—the Pendant two-burner and the single-burner bracket lamp, and are intended to burn the Army Standard Mineral Oil of flash point not less than 135° *Fahrenheit.*

Pendant two-burner Lamp.

Form and material.—To be of form and materials according to the standard sample.

Font-holder.—The font-holder (part No. 1) to be made of sheet brass No 22 (American standard gauge), and to be put together with hard solder, *i. e.*, to be brazed and spun over to harden and stiffen the holder. Diameter at top, four and a half ($4\frac{1}{2}$) inches; at base, two and a half ($2\frac{1}{2}$) inches; at center, three and five-eighths ($3\frac{5}{8}$) inches, gradually increasing and diminishing respectively to the above dimensions. The top to be slightly flared and its edge turned over to form a bead one-eighth ($\frac{1}{8}$) of an inch in diameter. Holes for wire arms to be one-fourth ($\frac{1}{4}$) of an inch in diameter, and to be on opposite sides of the holder, at a distance of one (1) inch from the top. Air vent-hole, one-eighth ($\frac{1}{8}$) of an inch in diameter, pierced one and five-eighths ($1\frac{5}{8}$) inch from the top. Arms (part No. 2) to be of No. 3 standard gauge brass wire, drawn hard, with eyes bent on ends one-half ($\frac{1}{2}$) inch in diameter, tips pointed. Base of arms to pass through cast and turned brass sockets (part No. 3) and be securely riveted on interior of font-holder. The brass socket to be one (1) inch long, three fourths ($\frac{3}{4}$) of an inch diameter at base, one-half ($\frac{1}{2}$) inch diameter at smaller end, and be milled off so as to fit surface of font-holder and be soft-soldered to it. Spread of arms about eleven (11) inches. Bottom (part No. 4) to be a brass casting, turned on the interior so as to fit lower edge of font-holder, and be turned, all on the outside. The inside surface at the branch-holes to be raised to a height of about one fourth ($\frac{1}{4}$) of an inch, full, to afford proper support to the branches when connected. The holes for branches to be of proper size and to be one and nine-sixteenths ($1\frac{9}{16}$) inch apart, measured from center to center. This bottom casting to weigh not less than five and one-half ($5\frac{1}{2}$) ounces, and be attached to the font-holder with soft-solder.

Branches.—Two branches (part No. 5) to be made from brass tube of gauge No. 14, American standard, one-half ($\frac{1}{2}$) inch outside diameter, and weighing about four and a half ($4\frac{1}{2}$) ounces to the foot. Soft-soldered to the bottom of font-holder, and extending from it in a curve to the burners, to which they shall be attached also with soft-solder. The burner end of each branch to be provided with a cast connection (part No. 6), milled and fitted to same so as to form a strong and tight joint. Distance between center of burner and center of font-holder eight and one-half ($8\frac{1}{2}$) inches. Depth of curve of branch about four (4) inches from bottom of font-holder.

The suspending supports (part No. 7) to consist of two (2) brass-wire rods and a ring, all of gauge No. 9. The rods to be fourteen and three-quarters ($14\frac{3}{4}$) inches long when finished, bent in half ($\frac{1}{2}$) inch eyes on ring, and having half ($\frac{1}{2}$) inch **S** hooks, with tapered points on ends to hold the font-holder arms. Inside diameter of ring one and a half ($1\frac{1}{2}$) inch.

Burner.—Argand burner according to pattern. Diameter of oil-reservoir (part No. 8), one (1) inch, gauge No. 26. Length, five (5) inches; pitch of threads, two (2) to the inch; depth of thread, three thirty-seconds ($\frac{3}{32}$) of an inch; width of thread, three thirty-seconds ($\frac{3}{32}$) of an inch; gauge of metal where oil-drip screws on, No. 21, made from seamless tube. Center tube (part No. 9), five-eighths ($\frac{5}{8}$) of an inch diameter, gauge No. 26; length five and a half ($5\frac{1}{2}$) inches, attached to oil-reservoir with soft-solder. Oil-drip (part No. 10), one and three-fourths ($1\frac{3}{4}$) inch in diameter, and one and one-fourth ($1\frac{1}{4}$) inch deep, exclusive of knob; gauge of top, No. 20, of bottom shell, No. 24, the latter to be provided with a cast-brass knob, and be well filled with solder to prevent denting Wick-raising tube (part No. 11), four and three-fourths ($4\frac{3}{4}$) inches long, and of diameter to fill oil-reservoir; top closed in to seven-eighths ($\frac{7}{8}$) of an inch diameter, seamless tube. Chimney-holder (part No. 12), a seamless shell, two and one thirty-second ($2\frac{1}{32}$) inches in diameter outside; gauge, No. 25; height, one (1) inch; shell made to ship chimney-holder (part No. 13), according to pattern, gauge No. 24; cone to fit shell, gauge No. 24. Tube-slide (part No. 14), of gauge No. 26, to fit over thread of reservoir and be clinched fast to burner-shell; top part to be closed in and riveted to wick-raising tube. The chimney-holder to be made detached from shell, so that it may be lifted off with chimney when lighting lamp.

Reflector.—A brass reflector (one for each lamp), part No. 15, nickle plated, gauge No. 25; diameter, ten (10) inches; depth, three and one-half ($3\frac{1}{2}$) inches; edge turned over to form a one-eighth ($\frac{1}{8}$) inch bead. Chimney-hole, two and one-fourth ($2\frac{1}{4}$) inches in diameter. Arms of No. 9 hard brass wire, riveted to a solid ring, which shall be two and one thirty-second ($2\frac{1}{32}$) inches in diameter (inside), five-sixteenths ($\frac{5}{16}$) of an inch deep, and No. 13 gauge; the ends of arms to be drilled, tapped, and fastened to reflector with screws. See also drawing, attached, of reflector of different make.

Font.—A heavy flint-glass oil-font of form and dimensions according to pattern, about eleven (11) inches high by about four and a half ($4\frac{1}{2}$) inches diameter at widest part, the top to be flattened so that the font will stand on a level surface unsupported while being filled; to have a bead or shoulder around it at proper distance from the top to support it on the upper edge of font-holder when in position; to have an opening at bottom, with funnel-shaped mouth, for convenience in filling, provided with self-acting valve in conformity with drawings and model. Capacity of font, three (3) pints.

Chimneys.—For each burner a chimney of the best flint-glass according to pattern; length about ten and one-half ($10\frac{1}{2}$) inches; diameter at base (inside) one and three-fourths ($1\frac{3}{4}$) inch, with shoulder at height of about two and one-eighth ($2\frac{1}{8}$) inches; upper flue, about one and one-eighth ($1\frac{1}{8}$) inch diameter.

The various parts of the lamp to be uniform, so that those of one will fit another, and the whole to correspond in design, finish, and construction with the drawings and the standard sample, and to be in no particular inferior to the latter. Where any differences are found to exist between the drawings and sample, the latter shall govern.

Each lamp when delivered shall be provided with wicks and be in complete order and ready for use upon being filled with oil.

For the guidance of manufacturers the weights of the various parts of the lamp are given below:

No. of the part.	Name of part.	Pounds.	Ounces.
1	One font-holder		$13\frac{14}{16}$
2	Two font-holder arms		$3\frac{6}{16}$
3	Two font-holder arm sockets		$1\frac{10}{16}$
4	One font-holder bottom		$5\frac{8}{16}$
5	Two branches		$10\frac{7}{16}$
6	Two branch connection sockets		$\frac{12}{16}$
7	Suspending supports		$5\frac{8}{16}$
8	Two oil cylinders		$2\frac{10}{16}$
9	Two center tubes		$2\frac{13}{16}$
10	Two oil-drips		$2\frac{2}{16}$
11	Two wick-raising tubes		2
12	Two tube-slides		$\frac{6}{16}$
13	Two shells		3
14	Two chimney holders		2
15	Two chimneys		$7\frac{8}{16}$
16	Reflector (one)		$10\frac{8}{16}$
	Glass font (one)—not less than	2	
	Total weight of lamp complete	6	10

Exclusive of the glass parts (the font and chimneys), which are liable to vary considerably in weight, the average lamp should weigh, when finished, about four pounds and two and a half ounces (4 lbs. $2\frac{1}{2}$ oz.).

Single-burner Bracket Lamp.

Font-holder.—The font-holder to be as described for double-burner lamps, except that it be without wire arms, and have but one branch and burner.

Other parts.—The burner, glass font, branch, chimney, and reflector to be as described for the double-burner lamp.

Bracket.—A japanned, malleable-iron supporting bracket, with socket to receive font-holder, according to the standard sample. Weight of bracket about thirteen ounces (13 oz.).

The weight of the bracket lamp to be the same as given for the double-burner pendant lamp, deducting that of the suspending supports, the arms of font-holder, and one branch, with its burner and chimney, and adding that of the bracket—making its average weight (exclusive of font and chimney) about three pounds and eight ounces (3 lbs. 8 oz.).

(Signed) JOHN F. RODGERS,
Captain and M. S. K., U. S. A.

PHILADELPHIA DEPOT OF THE
QUARTERMASTER'S DEPARTMENT,
Philadelphia, October 7, 1881.

Army Lamp
Two Burner, Pendant.

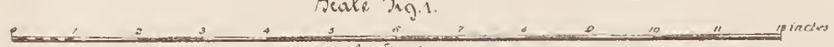
M. C. Meigs
Quartermaster General
Brt. Major General U.S.A.

Washington October 5. 1861

Fig. 1.

Fig. 2.
Plan of Support of Reflector

Scale Fig. 1.



Scale Fig. 2.

Army Lamp
One Burner, Bracket.

M C Meigs
Quartermaster General
Brt. Major General U.S.A.

Washington October 5. 1861.

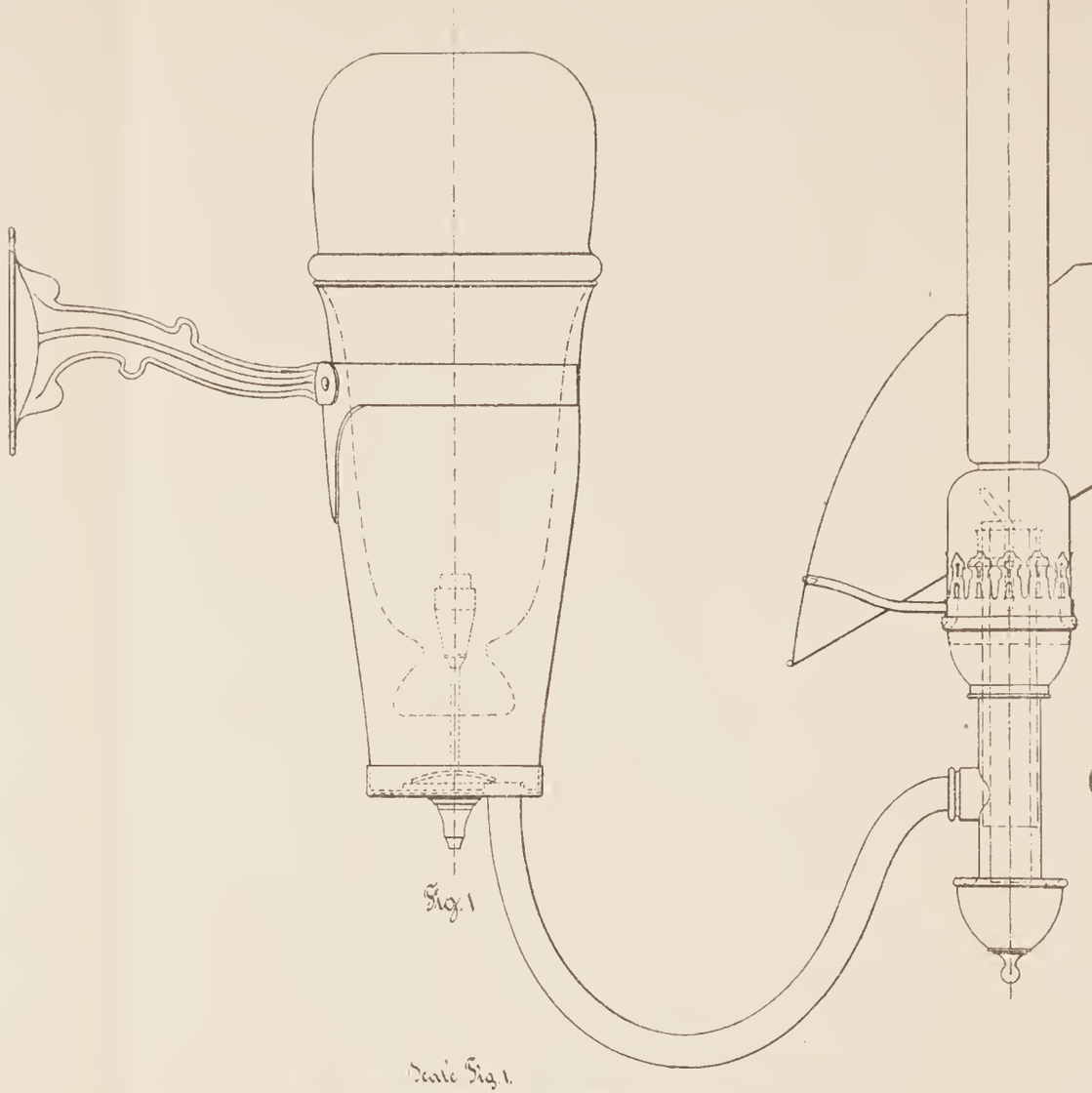
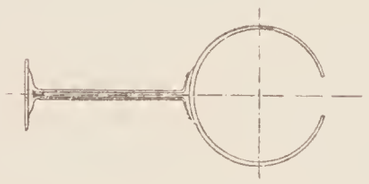


Fig. 1



Top View of Malleable iron Bracket
Fig. 2.

Scale Fig. 1.

Scale. Fig. 2.

Reflector of Parabolic Form for Army Lamp properly adjusted.

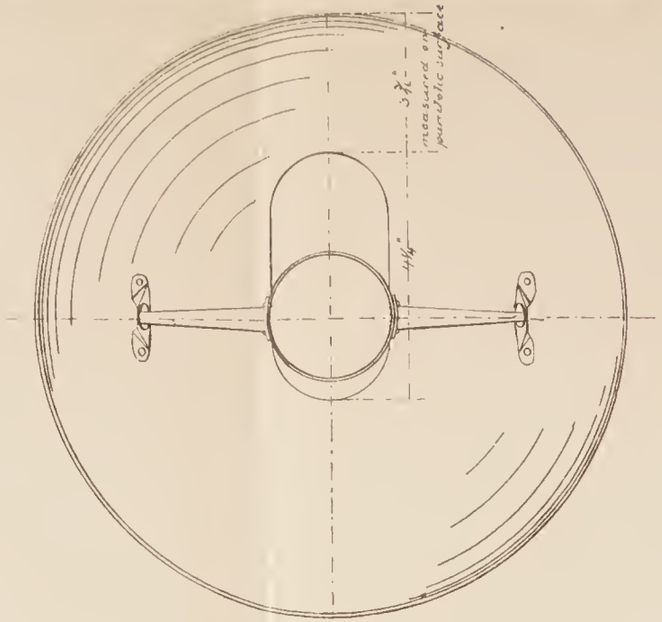


Fig. 1.

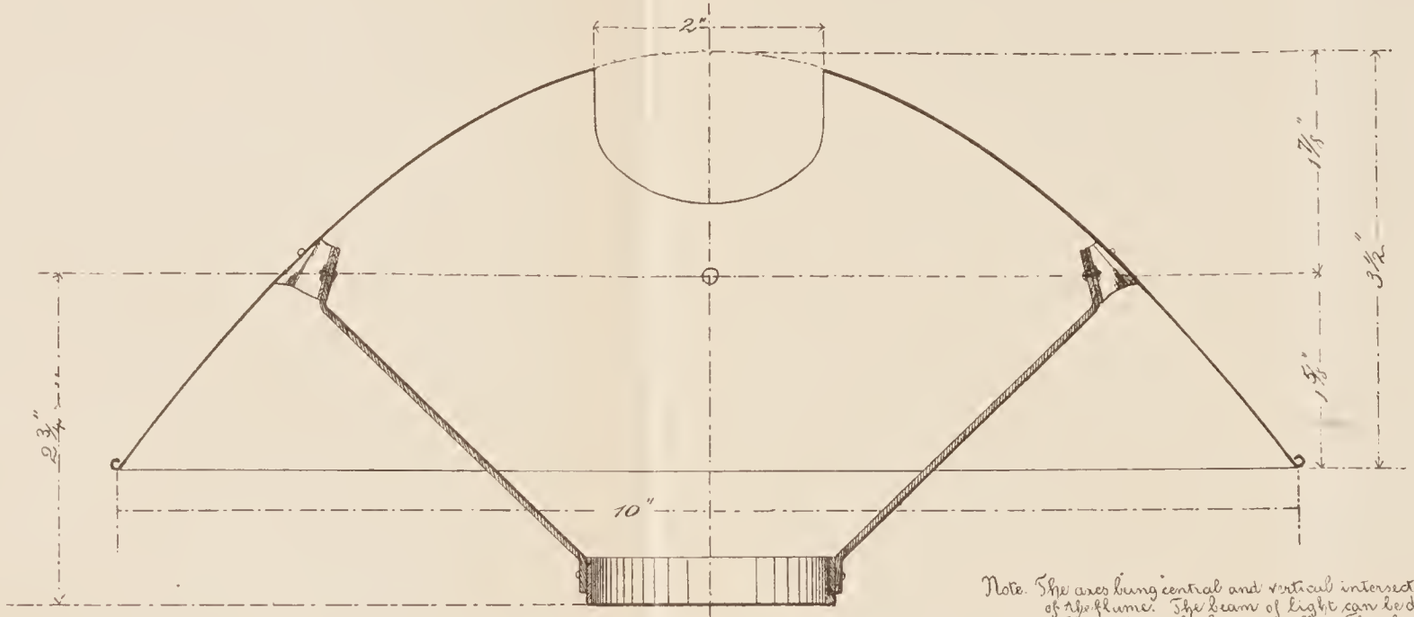


Fig. 2.

Scale for Fig. 1.
0 1 2 3 4 5 6 7 8 inches

Scale for Fig. 2
0 1 2 3 4 inches

Note. The axes being central and vertical intersect in the brightest part of the flame. The beam of light can be directed (by tilting the reflector) nearly horizontally. The chimney opening is 2 inches wide and 4¾ inches long, and reaches to within 3 3/16 inches of one edge. A rivet and washer secure each arm to the reflector, & by means of a band fastened with rivets, tight enough to keep reflector in any position by friction.

Official. Prepared by direction of the Quartermaster General U. S. Army.

Henry Stroyes.
Deputy Quarter Master General.